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Curculio Investigations

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# " CURCULIO INVESTIGATIONS"

by

# JAMES RICKETTS SHINN

Thesis for the Degree of Bachelor of Science

in the

COLLEGE OF AGRICULTURE

of the

UNIVERSITY OF ILLINOIS

June 8, 1904



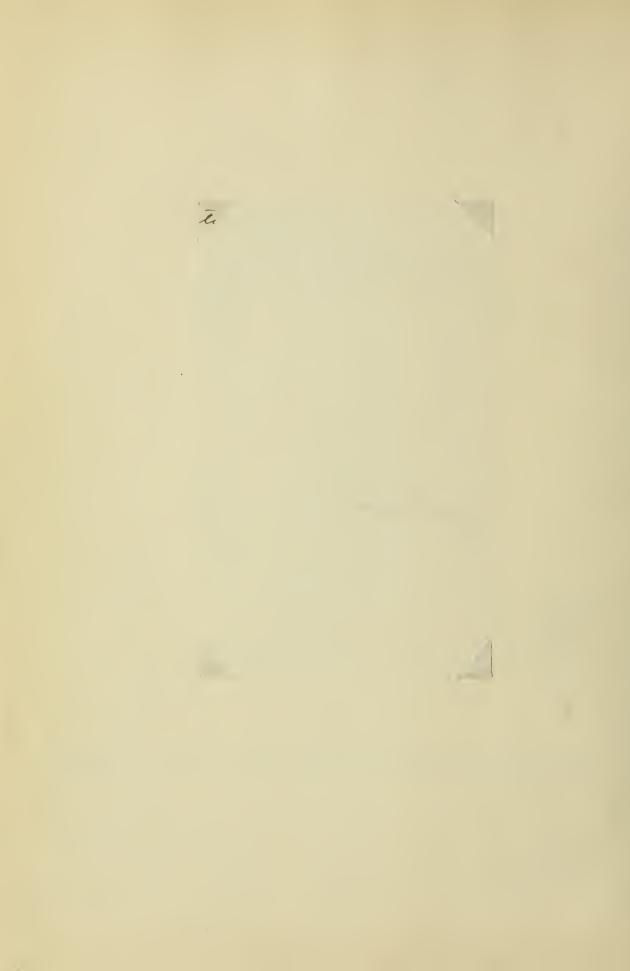
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	May 30,	1904
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	James Ricketts Shinn	
ENTITLED "CU	erculio Investigations"	
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Where the Beetles Grew, With the Author Ready for Business.



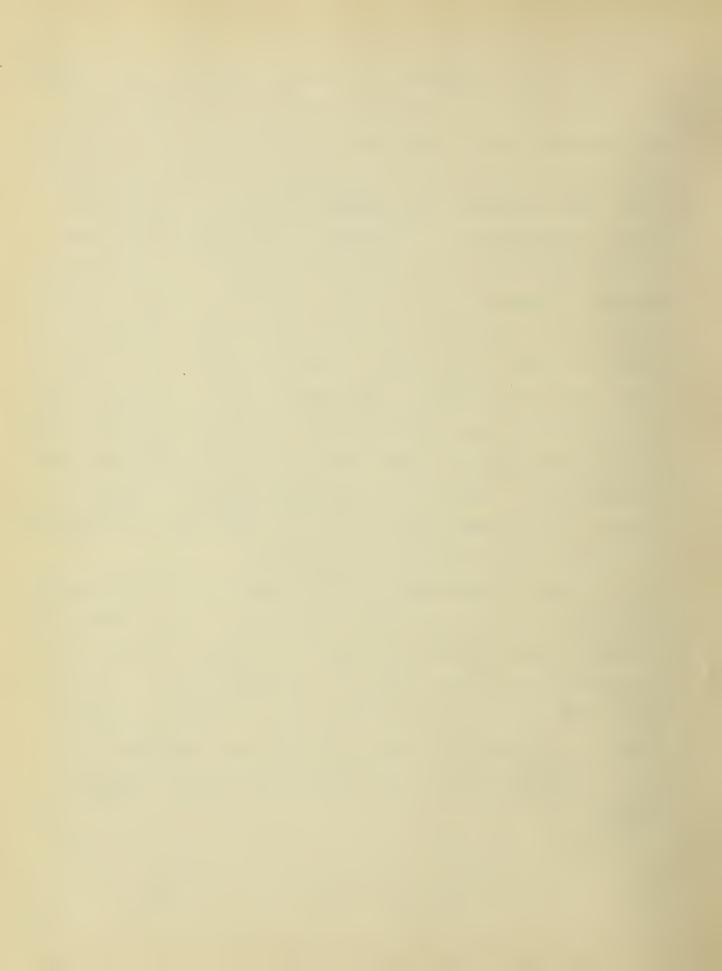
#### INTRODUCTION

During the fall of 1902, shortly after the opening of college, a consultation was held between Professor John W. Lloyd and the author regarding a prospective subject for a thesis. The latter desired a subject which would have a practical bearing upon horticulture, one which could be worked upon during the summer-vacation of the year 1903, and one which could be depended upon to lend a great amount of interest as the work proceeded. After discussing several possible avenues along which investigations might be pursued, it was finally decided that no more important line of work could be taken up than that of trying to combat the curculios by means of spraying with Paris green. At just about this time, Messrs. Albert Blair and John R. Williams of St. Louis, Mo. had applied to the Department of Horticulture of the University of Illinois for assistance, in order that they might ascertain some remedy for ridding their orchards, near Barry, Pike County, Ill., of these pests. Professor Lloyd mentioned this incident and proposed that the author should aid the cause by getting information in the above mentioned Accordingly, plats were 'laid out in the Plum and Variety Orchards on the Experiment Station grounds. The late freeze on May 1st destroyed all the plums so the spraying work with the plums as abandoned, although two applications were made on April 15th and May 5th. The greater portion of the apples, which were Ben Davis, was also destroyed at this time; still, enough remained to warrant continued work.



Late in June Professor C. S. Crandall suggested that I should go to Barry, where the Experiment Station had undertaken quite extensive work upon the curculios and where these insects were much more abundant than they were at Champaign, in order that I might gather some information also for the Department of Horticulture. After due consideration, I decided to co-operate with the above mentioned Department, made preparations to leave the work at the Station in charge of Mr. R. B. Howe, and went to Barry on June 29th. Practically all the work upon the habits and life historics of the insects was made at that place. Not being able to get to Barry sooner than the above date, I was unable to make as detailed notes as I would have wished; nevertheless, there was no lack for things to do and from start to finish there was interest and suggestiveness in every detail. Many of the questions suggested, I sought to answer; but many were left untouched and still offer an opportunity for a great amount of careful investigation.

I wished to acknowledge the help rendered me by Professor Crandall, under whose charge the work was pursued. He was always ready to suggest ways of getting solutions for problems and by personal supervision and interest, greatly encouraged the work. A great proportion of the following investigations was taken up directly under his direction and it was largely by plans formulated by he and I, working together, that what has been achieved was accomplished.



## INSECTS WORKED UPON.

Two different insects, known as curculios, were the subjective material for the investigations which were pursued during the summer.

The plum curculio (Conotrachelus nenuphar Herbst) is a small beetle, 5.0 m.m. in length and 2.5 m.m. in width, somewhat boat shaped in form, of a brownish color, with the upper surface characterized by its roughness and distinctive markings. Rough, continuous ridges, run laterally along the wing covers. Upon the uppermost ridge of each wing cover there are two distinctive, sharpedged, black humps. Between these humps the coloring is black so that to the unaided eye there appears to be one large black spot on the back of the insect. Immediately behind these larger humps there is a band of very light brown extending nearly across each wing cover. Behind the band the roughened portion contains a gentle dash of white. The foremost portions of the two uppermost ridges upon the wing covers are marked with white which extends to the prothoracic segment, making two small streaks of white, widening and terminating behind the eye. Upon the other portion of the upper surface of the insect the brown receives an occasional sprinkling with small, black dots. The under portion of the body is very dark brown or almost black. The curved beak or proboscis is of a brown color, terminating in black at hend and measures .07 inch long by .016 inch wide. Near the end on the under side of this proboscis the transverse-working mandibles are situated. A pair of ever moving antennae are carried at the side of this proboscis,



being fastened to it about one-third its length from the end. The three pairs of legs are almost the same length so that the lower portion of the body is almost parallel with the surface over which the insect walks.

The apple curculio (Anthonomus quadrigitbus Say) is a small beetle 3.7 to 5.2 m.m. in length and 1.8 to 2.5 m.m. in width, oval in form, of a light brown color, with a distinctive long beak and a very long pair of prothoracic legs. Rough, continuous ridges run lengthwise on the wing covers and the two wing covers meet each other in a prominent ridge, making a line bisecting the body. each side of this middle ridge, at the point where the wings curve abruptly downward, there is found a very prominent hump; while just preceeding each of these humps there is another one, very much smaller in size. (From these four humps the beetle derives its name, i.e., quadrigibbus - the four humped.) In some instances the wing covers become quite grayish on top, especially so with the males, but their usual color is light reddish brown. boscis of the apple curculio is much longer and somewhat more slender than that of the plum curculio, being .102 to .131 inch long and .014 to .015 inch wide. The mandibles and antennae occupy about the same relative position on this proposcis as the same parts do in the case of the plum curculio. The prothoracic legs exceed very much the length of the other two pairs of legs which causes an elevation of the anterior portion of the body at quite an angle above the posterior portion when the beetle is at rest.





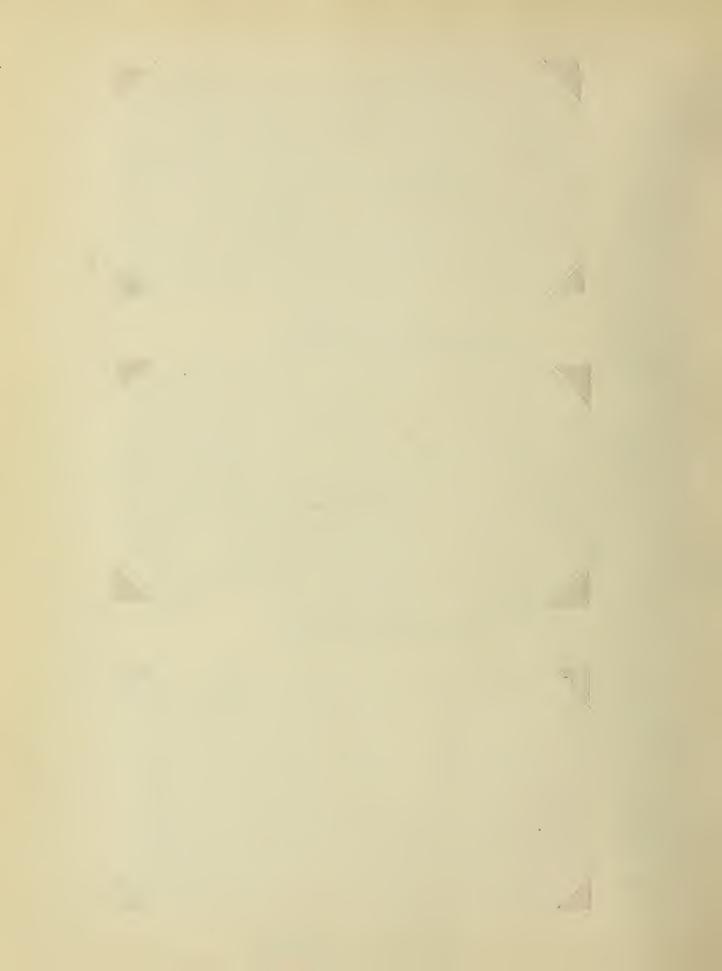
THE APPLE CURCULIO (Anthonomus Quadrigibbus )



THE APPLE CURCULIO (Anthonomus Quadrigibbus)



THE PLUM CURCULIO (Conotrachelus nemuphar)



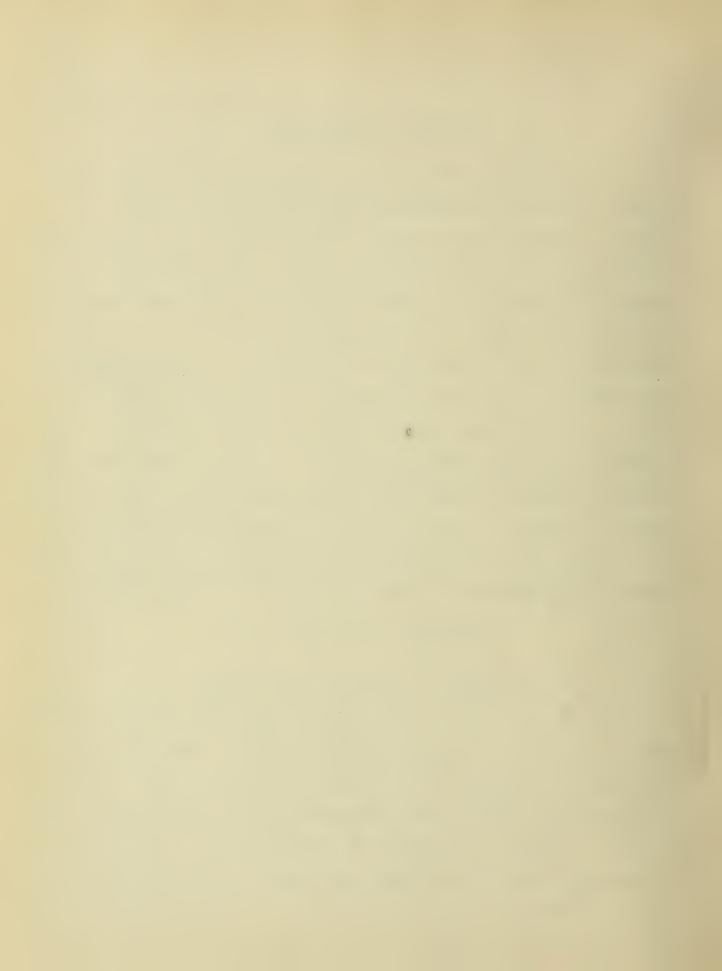
### POISONING EXPERIMENTS

Two of the most satisfactory methods of eradicating chewing insects are found in applying arsenicals or other poisons in the form of a liquid or dust spray, in such a manner that all portions of the food plant are coated with poison. The former method, as far as experience is concerned, has for its endorsement, economy of both labor and money, is well adapted to orchard use, and, where the poison is used in sufficient amounts and is properly applied, the outcome is always very effectual in attaining the desired results. If arsenicals, notably Paris green and lead arsenate, are capable of poisoning these curculios, it occured to the author that through their use, a means was offered whereby these noxious insects could be combated. For the purpose of determining whether or not the curculio could be poisoned and what amounts of poison or arsenicals would be required the following experiments were undertaken.

## EXPERIMENT I - Paris green.

Preparation of Mixture and Fruit.

The weighing scales which I had at my service were not adjusted so as to weigh less than one-half an ounce. This amount of Paris green was weighed out and placed in a small vial. By use of a measuring rule the vial was marked into six equal parts. By carefully transferring one part of the Paris green, .083 oz., to a gallon of water and thoroughly agitating, a thorough mixture was secured which was known as Mixture No. I. In this mixture Apple No. I was dipped and then allowed to dry in the air before being



placed in a common glass fruit-jar where it was subjected to the ravages of the plum curculios. By adding another portion of Paris green to this mixture, Mixture No. II was prepared, into which Apple No. II was dipped. Adding another portion to Mixture No. II, Mixture No. III was prepared, into which Apple No. III was dipped; and by adding another portion of Paris green to Mixture No. III, Mixture No. IV resulted, into which Apple No. IV was dipped. All apples were treated precisely as No. I.

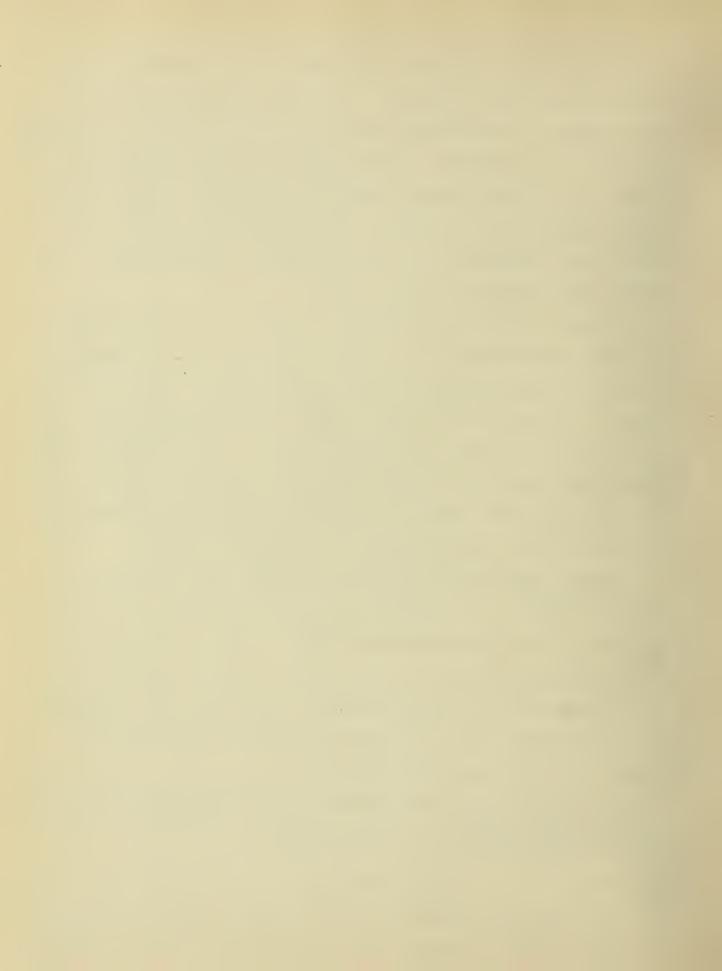
By this method of procedure, the treatment applied to Apple No. I was approximately the same as where 4 oz. of Paris green are used to 50 gallons of water; that treatment which Apple No. II received, approximately the same as where 8 oz. Paris green are used to 50 gallons of water; that which Apple No. III received, approximately the same as 12 oz. Paris green to 50 gallons of water; and that treatment which Apple No. IV received, approximately the same as 16 oz. or 1 lb. Paris green to 50 gallons of water.

Another apple which was known as "Check" was also used in this experiment; it received no treatment whatever. Also, in connection with and constituting a part of this experiment, an attempt was made to solve another problem, that is, how long does it take Paris green to deal disastrously with the plum curculios? For this purpose slices of apples coated with Paris green were placed in a fruit jar, known as No. 5.

All apples, after being properly dried were placed in properly and correspondingly labelled fruit jars.

### THE CURCULIOS.

The plum curculios which were to be used in this experiment had been confined in a glass fruit jar and all had been without



food for at least twelve hours; in fact most of them had been without food for thirty-six hours. Ten curculios were placed in each fruit jar.

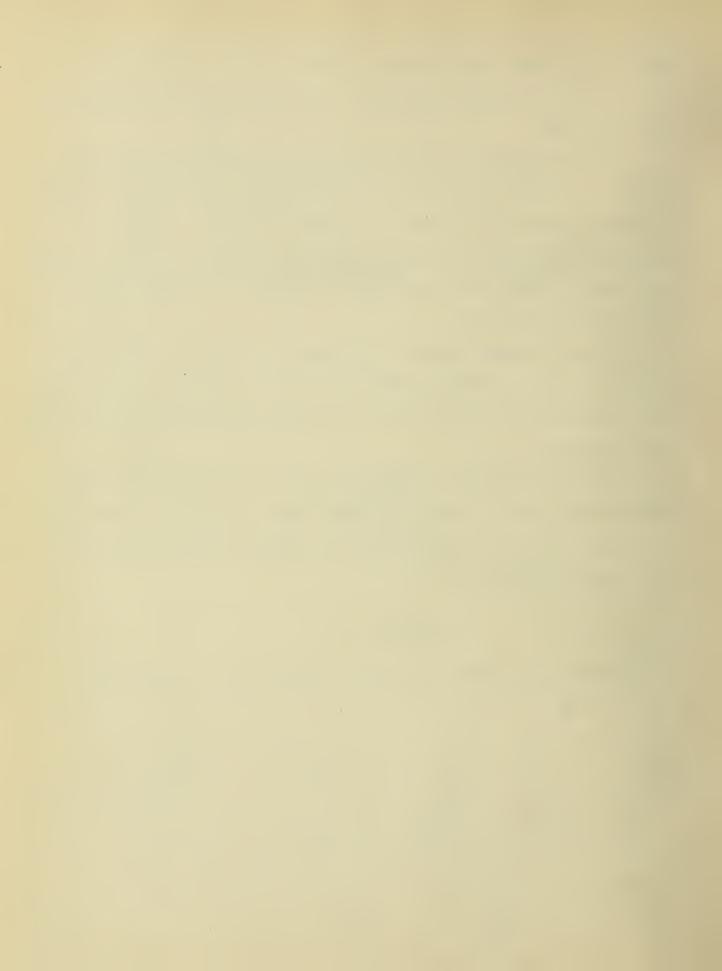
At the beginning of the experiment the curculios were very hungry. This was evidenced, not only by the fact that the curculios began feeding at once upon the apples, but also, because the curculios remaining in the confining jar, attacked slices of apples given them in much the same manner as a litter of hungry pigs attack a trough of swill.

The apples used in this experiment were sound in every respect, so that no lodgment place was left upon their surfaces where Paris green would collect to give the feeding insects a concentrated dose of poison.

After introducing the curculios into their respective jars, cheese-cloth, held in place by rubber bands, was used to close each jar, and, besides serving to keep the curculios from escaping, allowed good ventilation.

#### RESULTS.

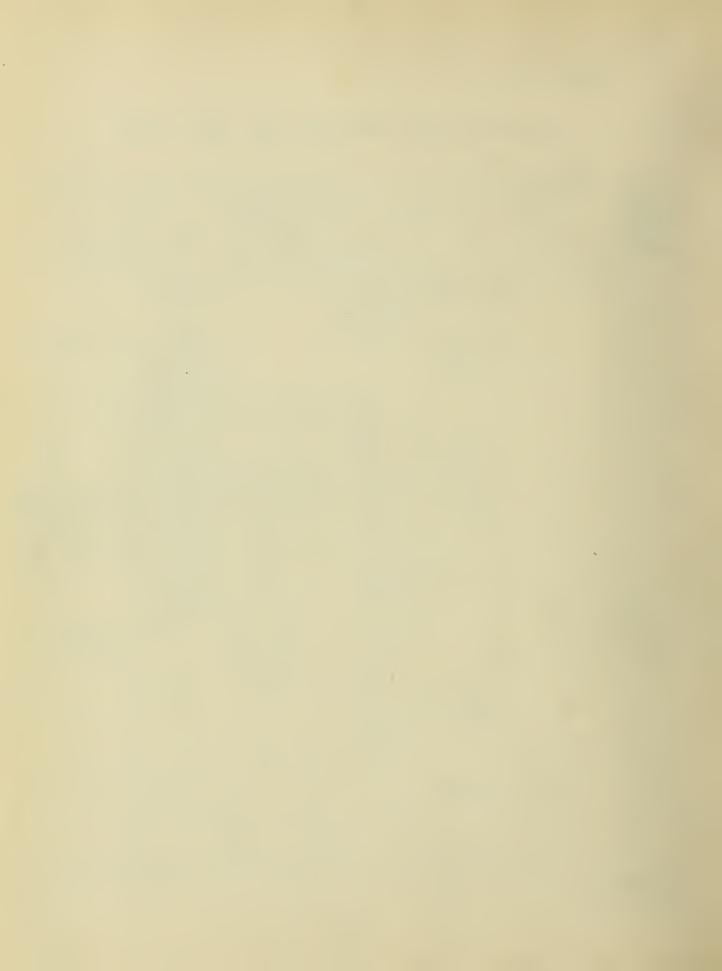
The following table shows the results of this experiment .-



# TABLE NO. I.

# POISONING PLUM CURCULIOS WITH PARIS GREEN

Hrs.	*												
Exp.in			N	u m b	е	r	0	f	Ja	r			
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2	: 11	11				ppar-		11	11		1 dead	: 1	11
1	•		•	:6	ntl	y dea	ad:			:		•	
3	: 11		:3 app		2	dead		17	11		1 dead &	:( no	record)
	•		ently		0	49	:	4.0			l dying	• 11	†1
4	- 11	.11	: 3 de	ad :	2	11		17	††		1 dead & 2 dying	: "	73
5	- • :1	17	· : 3 !!	•	2	heah	۶. ۰	2 4	appar-		1 dead &	• 11	11
	e n		• •								2 dying	•	
6	- 11	11	: 3 de								2 dead 8	11	19
	•		:l sic	k:	1 d	lying		S	ick		3 sick	:	
7	. 11	11									2 dead 8	:: 11	. #
	•		:l_sic			sick					3 sick	:	
8 :	n 99	11									3 dead 8		
9	- 19	11	:1 sic : 5 de						sick dead		5 sick 6 dead 8		
9	. "		. 5 ac	au.	4	ucau	•	'£	ucau		4 sick	. 0	ueau
11	• •	11	: 5	11 :	5	dead	%:	6	dead		6 dead 8	:(no	record)
, at an	•		:			ick				:	3 sick		,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,
13	: 11	11	: 5	m :	5	dead	&:	6	dead		7 dead 8	: 11	tt
(	•		•			ick					3 sick	:	
24	• 11	11	: 5	η :						&:	10 dead		
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50	- 11	11	• 5 40			dead						•	
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72	- 11	11	: 5 de			dead	&:	7	Ħ	:		:	
						sick						:	
96	: 11	17	: 6 "	:	7	dead	:	10	dead	:		:	
			:	:			•					:	
120	: 1	dead	: 10 d	ead:	8	11	:						
711	: : 7	11			8	11							
144	. /	•	•		δ								
168	: 8	17	e.		10	11	•			•		:	
100	:		•	•			•						
-				•									



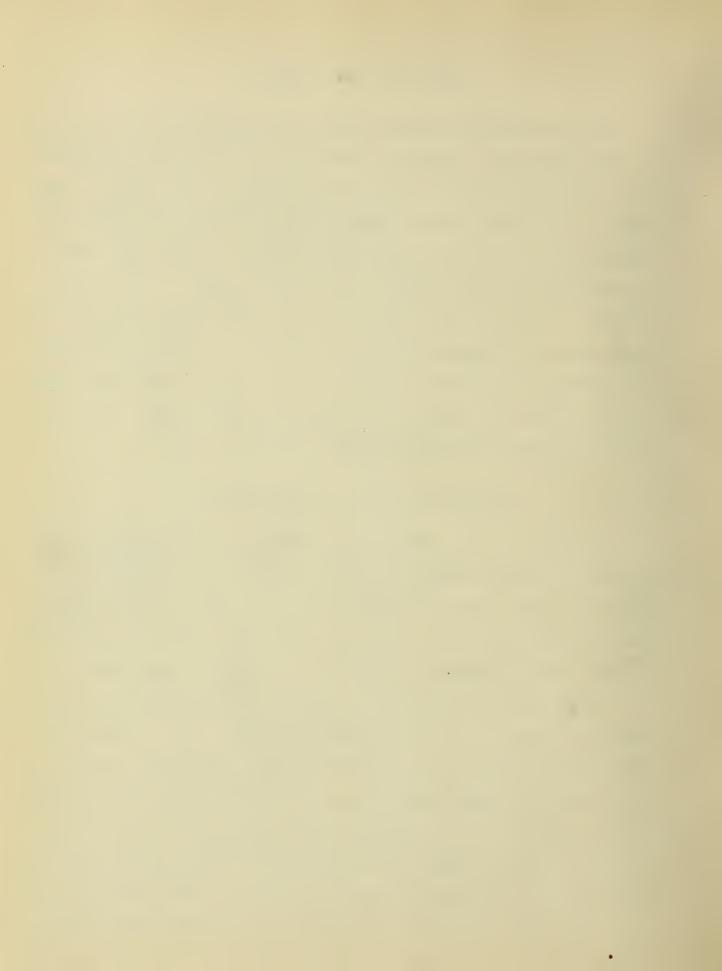
### DISCUSSION OF RESULTS.

This experiment indicates that plum curculios can be poisoned by Paris green and incidently shows that there is much difference in the susceptibility of individual insects to the poison. Small quantities of Paris green seem to affect some curculios much more rapidly than large quantities affect others. This can be seen by comparing jars No. I and II with III, IV, and V. In the end, however, it will be seen that it is the larger quartities of Paris green which effectually destroy the insects. Comparing all jars with Jar No. V, it will be seen that only one jar contained enough poison to kill the insects in a minimum space of time. This is Jar No. IV and it is closely followed by Jar No. III.

# EXPERIMENT II - Paris green.

In order to have somewhat of a check upon the preceeding experiment and also to make an effort to ascertain whether or not apple curculios could be poisoned by Paris green, another experiment was started on July 9th. The apple curculios fed so sparingly that this may account in part for the results shown below.

Preparations of mixtures, insects, apples and jars were made similar to those of the preceeding experiment. The "Chack" jar contained two unsprayed apples and ten plum curculios; Jar No. I contained two apples dipped in the mixture of .32 oz. Paris green per one gallon of water and ten plum curculios; Jar No. II contained two apples dipped in the mixture of .32 oz. Paris green per one gallon of water and ten apple curculios. The details of the experiment were practically the same as in the foregoing experiment,



### RESULTS

The results secured by this experiment are shown in the following table:-

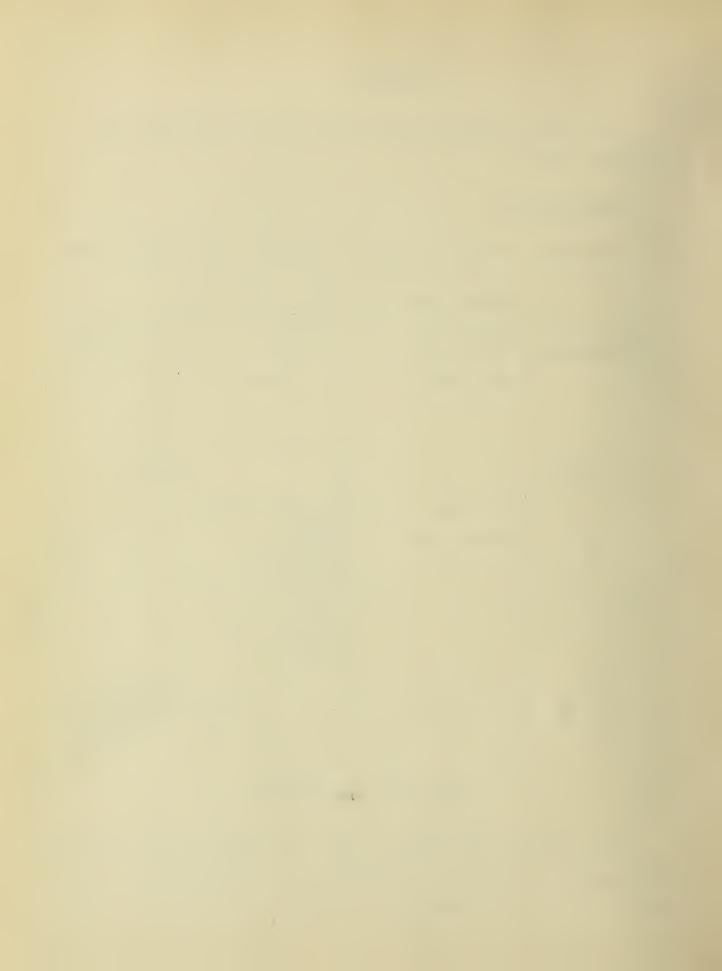
TABLE NO. II

POISONING PLUM AND APPLE CURCULIOS WITH PARIS GREEN.

Report on condition of Insects							
Hours Exp. in progress	Check Jar	Jar No. I	Jer No. II				
1	All living	All living	All living				
2	11 11	: 11 11	11 11				
3	11 17	One dead	11 11				
4.	11 11	Two "	ti ii				
5	Two dead	Four dead, three:	11 11				
6	Three dead	:Six dead, two : sick	11 11				
7	17 11	:Six dead, two :	17 17				
8	• 11 11	: sick : Eight dead, one : sick :	11 11				
9	11 11	:Nine dead, one	n n				
10	11 11	: sick :Ten dead.	11 11				
144	(No record)		11 12				

# DISCUSSION OF RESULTS.

The plum curculios used in this experiment had been confined for a number of days in a fruit-jar with a large number of others and owing to this probable over-crowding, it is likely that the health of the insects was impaired. It may be, too, that the time

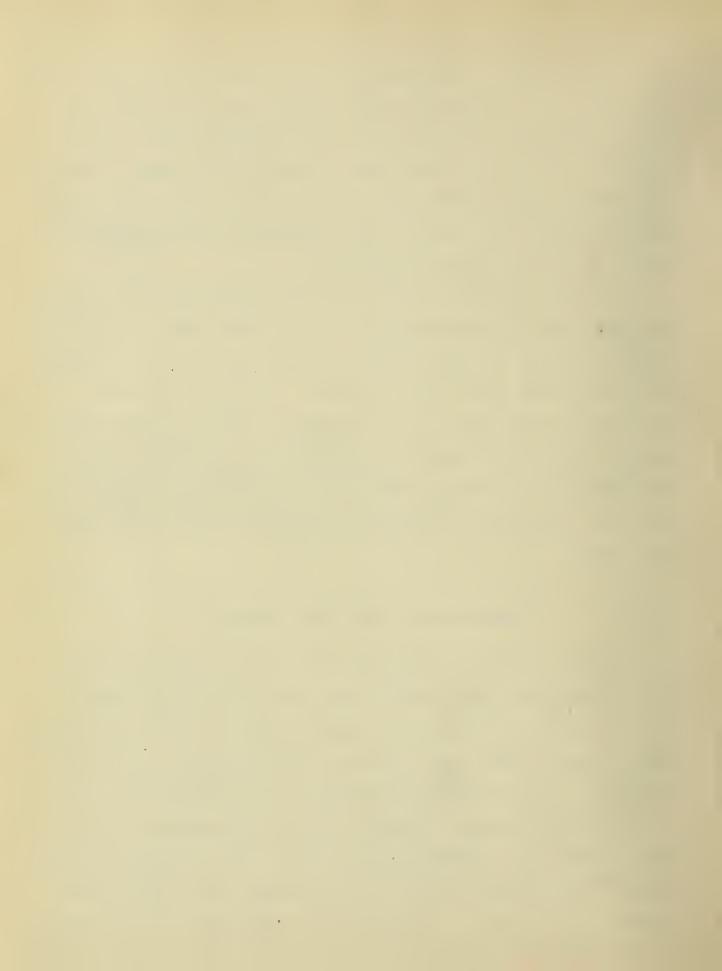


had come for many of the insects to die on account of old age. The inference that there was some such factor, as one of these, at work is borne out by the fact that three curculios died, within ten hours, while in the check jar. Granting that there was one or the other of these factors, or that both, were at work the results obtained in Jar No. I compare very favorably with those secured in Jar No. IV of the preceding experiment.

The results secured by the attempt to poison the apple curculios were not at all satisfactory. In the first place, very little feeding was done; and in the second place, most all of the feeding was done through two or three openings. From this it is not necessarily proved that it is impossible to poison the apple curculios, for, had they fed as heavily and as ravenously as they sometimes do, it is hard to see how they could escape without being poisoned. Further investigations are needed to give light upon this point.

### EXPERIMENTS WITH LEAD ARSENATE

On September 3rd I resolved to try lead arsenate as a poison for the plum curculios. Before this date, I had demonstrated through the use of the necessary amount of Paris green, the foliage would suffer so much, that the use of this arsenical would be impractical. Lead arsenate was known as an arsenical which would not injure the foliage, regardless of the concentration of the spraying mixture. Though costing far more than Paris green, because of this neutral effect on the foliage it had a very strong argument in its favor. Accordingly two experiments were undertaken one, where the apples were sprayed with the lead arsenate mixtures



while upon the trees, and another, where the apples were sprayed with the same mixtures after the apples had been removed from the trees.

## PREPARATION OF LEAD ARSENATE MIXTURE

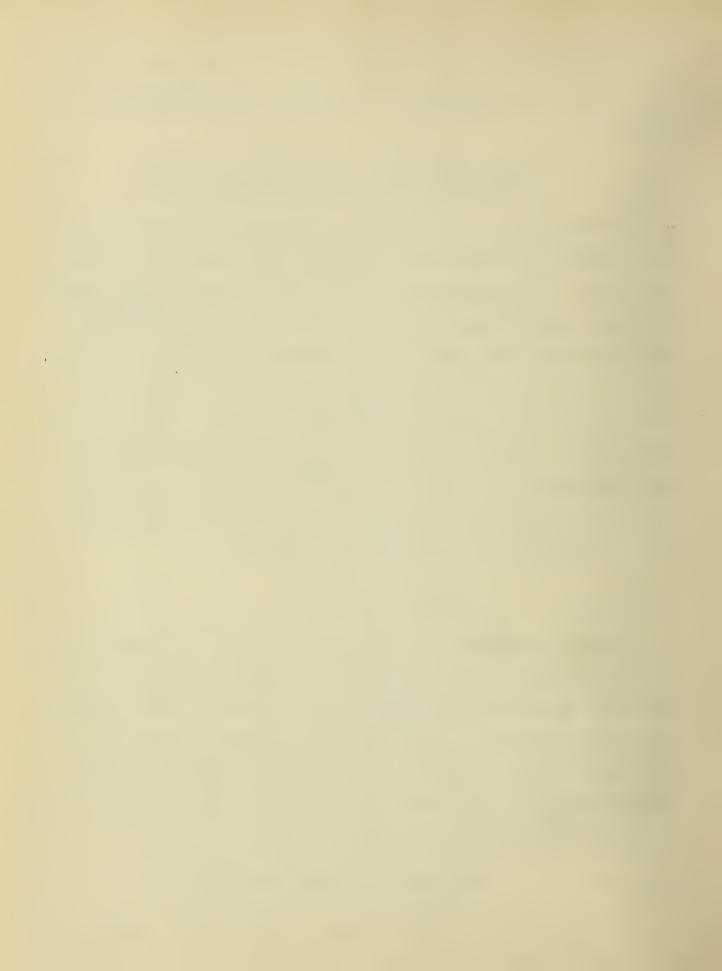
Fifteen ounces of lead acetate and six ounces of soda arsenate were weighed out accurately; dissolved each, separately, in small quantities of water; poured the lead solution into a bucket sprayer containing three gallons of water. The soda arsenate was then added, together with enough water to make four gallons of the mixture. The mixture was thoroughly agitated for several minutes so as to be sure that all reactions were complete. After my first lot of apples had been treated and one gallon of the mixture had been pumped out, one gallon of pure water was added making four gallons of mixture containing lead arsenate equivalent to 11-3/4 oz. of lead acetate and 4-1/2 oz. soda arsenate.

## FRUIT SELECTED

All fruit selected for these experiments had not been punctured by the curculios; it, therefore, contained no crevices for the lodgment of lead arsenate where the curculios would get a concentrated dose of poison. Two apples were allowed to remain upon the tree while all others were suspended from limbs by means of cords fastened to their stems until after spraying and drying, when they were suspended in glass jars.

#### SPRAYING AND OTHER TREATMENT

A common bucket sprayer was used to apply spray. Before each



application was made the mixture was thoroughly agitated and enough pumped out to be sure all liquid which remained in the hose from the previous pumping had been removed. Some of the apples were sprayed and others were dipped in the mixture. The apples which were sprayed received three applications. After the first and succeeding applications, each preceding application was allowed to dry before another was applied. Where an apple was dipped in the mixture, one application was all that it received. The object of spraying the three times was to make sure that all portions of the fruit was hit by the spray, and, when the spray had once dried it was very easy to tell what part of the fruit still needed spraying.

### THE CURCULIOS

Plum curculios were used in these experiments. Most of those used in connection with the apples remaining upon the tree had just lately emerged and had not been allowed any food. In fact they had never tasted an apple since they had left the fruit as larvae. The curculios used in connection with the apples suspended in jars were confined without food for thirty-six hours. Five curculios were placed within the cheese-cloth sacks where the apples were allowed to remain on the tree; while in each of the jars five were placed, excepting Nos. I and II which were allotted ten and seven, respectively.

## RESULTS

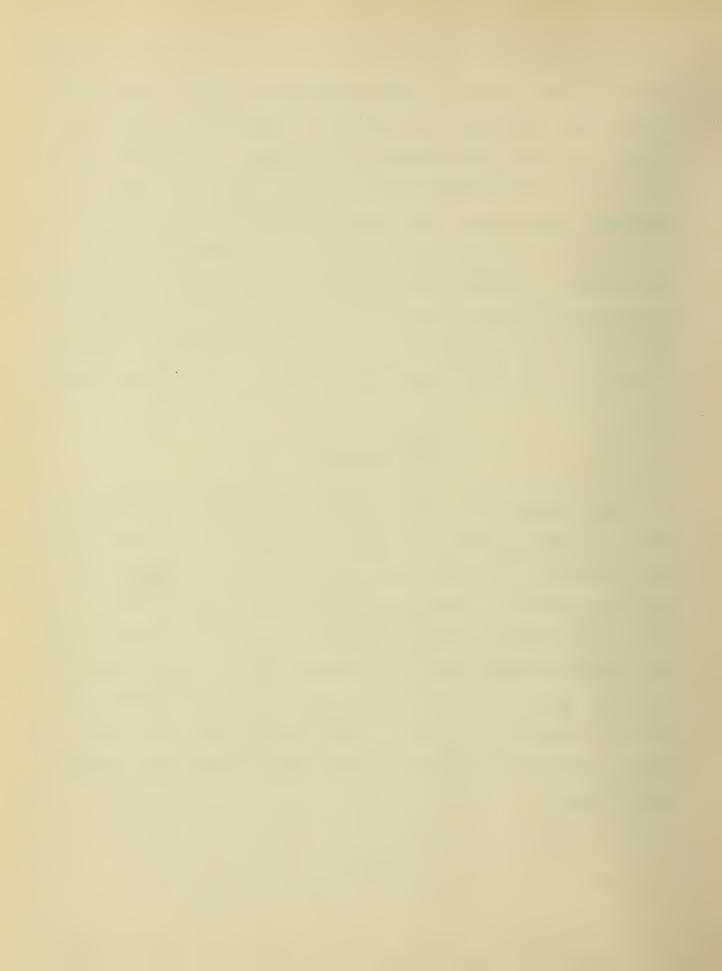


TABLE NO. III

POISONING PLUM CURCULIOS WITH LEAD ARSENATE

Apples sprayed on the tree.

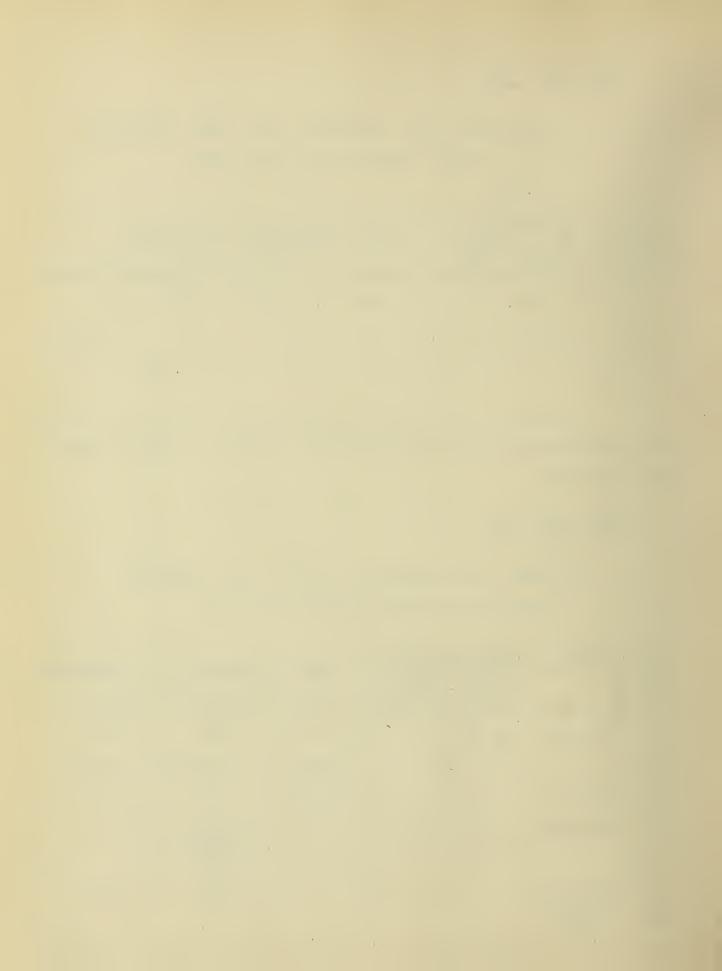
No. of	:Strength of 4 : :ga's. mixture :	Time	experiment	in progress.	
curculios	: Lead : Soda :		•	•	
	:acetate:arsenate:	48 hrs.	: 72 hrs.	: 84 hrs.:	240 hrs.
	: :		•	:	
5	: 15 oz: 6 oz:	3 dead	: 4 dead	: 5 dead :	
5	:11-1/4: 4-1/2:	7 11	. 2 "	3 <sup>11</sup>	7 dood
3		T	• 6		a dead

Perhaps the reason why the curculios in the last mentioned (less concentrated) trial did not die is because of their feeding very sparingly.

# TABLE NO. IV

POISONING PLUM CURCULIOS WITH LEAD ARSENATE
Apples sprayed and suspended in jars.

No.	: Kind of	:Strongt	h of 4	•		
					experiment	in progress
jar			Soda		: 72 hrs.	OO hma
	:	·acetate	arsenale	La III S.	· IA ILIS.	90 1115.
I	: Sprayed	15 oz.	6 oz.	no record	7 dead	10 dead
II	• ##	• 11 11	и п	2 dead	no record	no record
III	Dipped	11 11	11 11	no record	· 4 dead	5 dead
IV	: Sprayed	11-1/4	4-1/2	. ii ii	:4 dead and	5 "
	•		, , , , , , , , , , , , , , , , , , ,	•	: l sick	
V	ts	• #	11	• 11 11	: 3 sick	2 "
AI	:Sprayed &	• #	11	• 11 11	: 3 dead	3 dead
	: dipped	•		•	:	
VII	: Dipped	• If	11	• 17 2 <b>1</b>	: 2 "	2 "
	•	•		•	•	

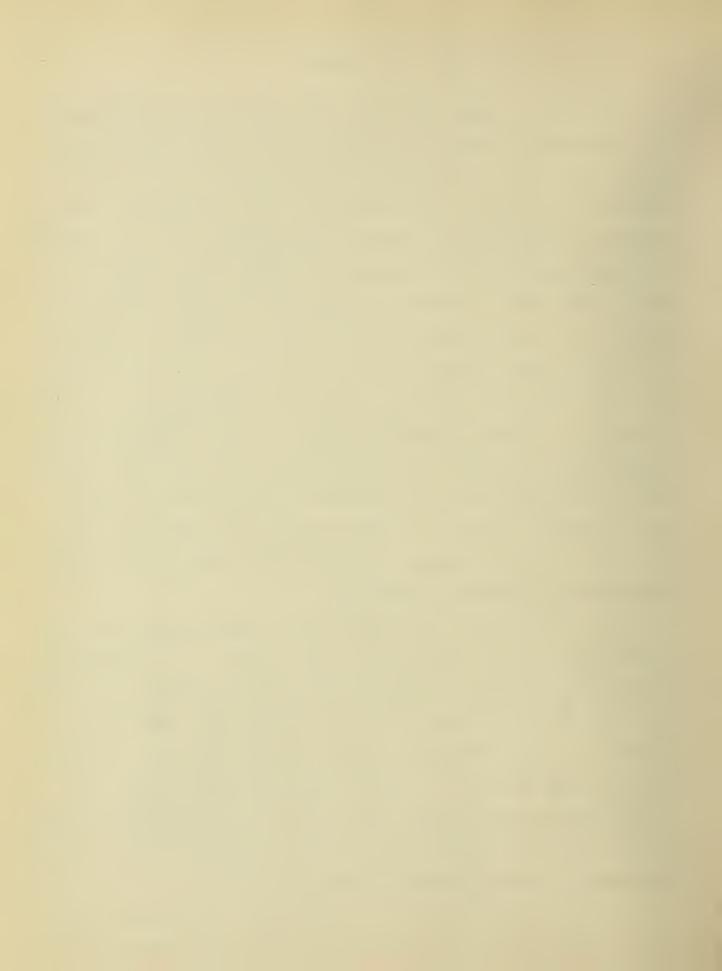


### DISCUSSION OF RESULTS

Both parts of this experiment with lead arsenate were brought to a close before they were entirely completed; nevertheless, the results show that it is unquestionably possible to poison plum curculios by the use of this arsenical. When a mixture of four gallons containing fifteen ounces of lead acetate and six ounces of soda arsenate are used as a spray the results show plainly that this is sufficient to produce poisoning and death with feeding curculios, while there is some indication that the same is true where a mixture of equal volume contains only 11-1/4 ounces lead acetate and 4-1/2 ounces soda arsenate; still the results are not secured as quickly. Either lead arsenate does not act as quickly as Paris green or else the dose which the curculios received in this experiment was not sufficiently concentrated to give the best results. Where it took at least over seventy-two hours to poison the plum curculios with lead arsenate, with Paris green only ten hours were required to accomplish the same end.

It is interesting to note how much and what would be the cost of lead arsenate for a mixture of fifty gallons. In the stronger mixture eleven pounds and 10-1/2 ounces of lead acetate and 4 pounds and 8 ounces of soda arsenate would be required for each fifty gallons, costing at wholesale prices, respectively, \$1.75 and \$.67; making a total of \$2.42. With the weaker mixture 8 pounds and 12-5/8 ounces of lead acetate and 3 pounds and 8-1/4 ounces of soda arsenate would be required for each fifty gallons, costing, respectively, \$1.34 and \$.53, making a total of \$1.87.

There are other factors to be taken into consideration in the results secured. To what extent did the curculios damage the



fruit used in the different instances? Where the Truit remained upon the trees, in the case where all the curculios were killed, before getting their deadly dose of poison, they failed utterly to pierce the flesh or even the skin of the apple. Besides, when this fruit was examined a month later there was apparently a good coat of lead arsenate still remaining to it, regardless of the fact that it had passed through some very stormy weather. However, the Experiment Station chemists failed to find the slightest trace of arsenic present. With the fruit on the tree receiving less poison several punctures were made into its flesh. Up until October 2nd, thirty days after spraying, the former fruit was in perfect condition while the latter was much decayed about the punctured places.

Examination of fruit from the jars revealed the following -

Jar No. 1. -

Only once place was found upon this fruit where the beettles had eaten into the skin but it was so slight that it would not blemish the apple. The poison was removed in four other places about the size of a pin-point.

Jar No. 2. -

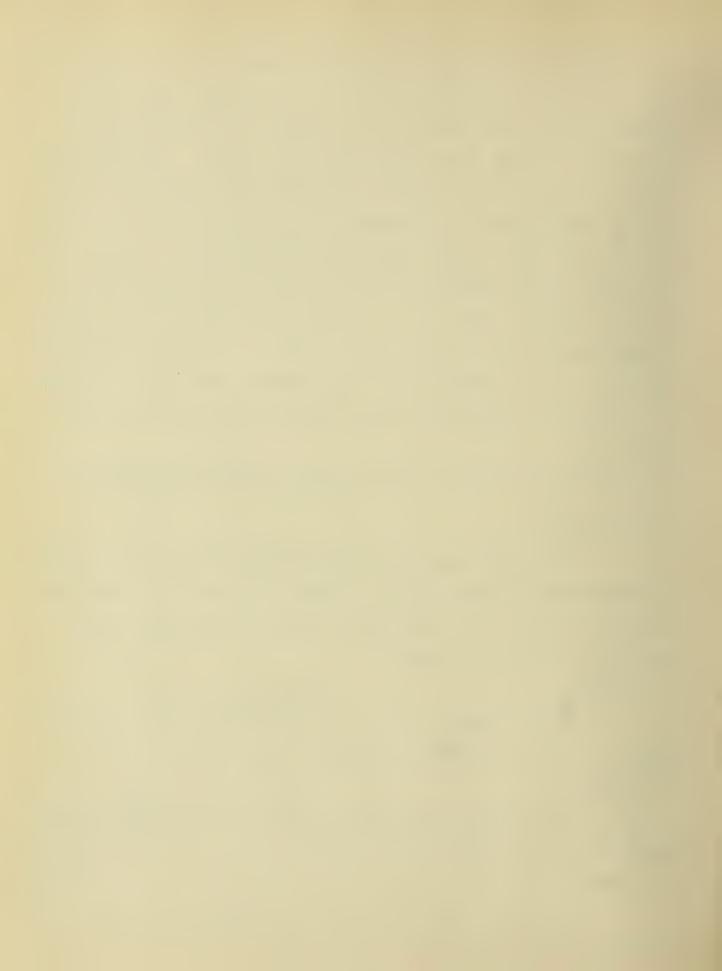
The skin was not broken on this apple although the poison had been removed in several small spots.

Jar No. 3. -

The poison had been removed from two small spots on this apple but the skin had not been broken.

Jar No. 4. -

The skin on this apple had been broken in two small spots where two shallow punctures had been made.



Jar No. V. -

Seven shallow punctures were found on this fruit.

Jar No. VI. -

Two small shallow punctures had been made on this fruit; the poison was also gone in spots.

Jar No. VII. -

Seven shallow punctures were the marks left by the curculios upon this fruit. These punctures were much larger than those found upon previous fruits examined in this experiment.

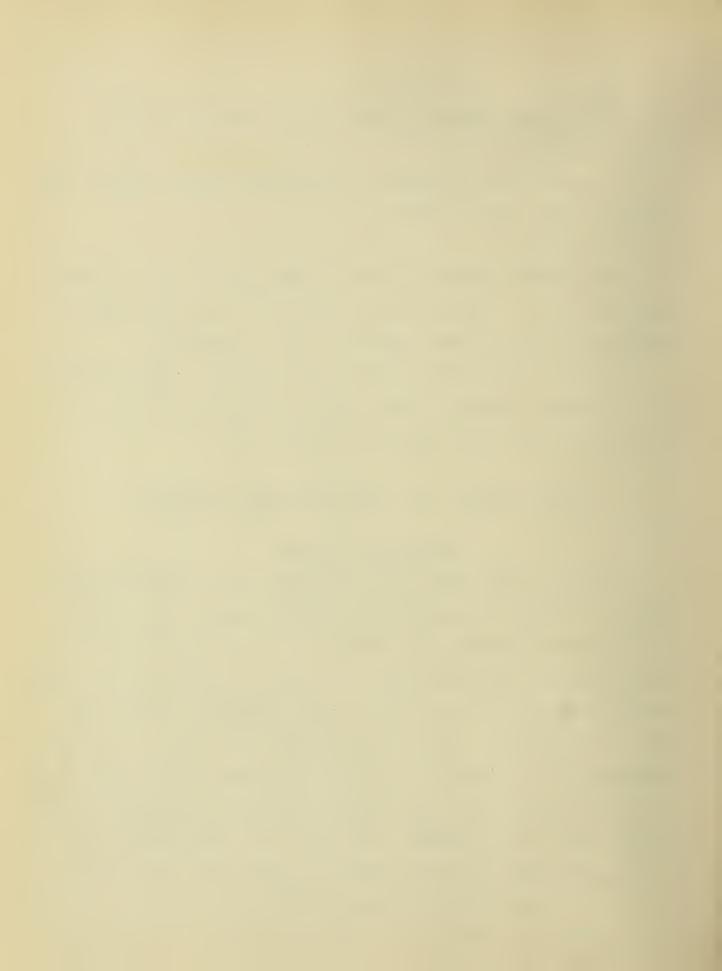
The effects upon the condition of the fruit is much in favor of the stronger formula. For, besides killing the insects, it protects the fruit from injury at the same time.

OTHER METHODS OF DESTROYING PLUM CURCULIOS.

# Exposure of Pupae.

As will be seen later from experiments upon the life history of the plum curculio, pupae of this insect remain in the ground in a helpless condition for a number of days and it seemed altogether possible that here might be a means of eradicating the insect, through exposing it to the air and other agencies above the surface of the ground. In order to determine the value of exposure of pupae to the air and to the heat of the sun, on July 25th, I placed five pupae upon moist, finely sifted soil immediately after taking them from the ground. At 11:50 A. M. I placed them out in the open where the direct rays of the sun might strike them.

(I think the temperature was fully 100 Fahr. in the shade.) I watched them very closely for twenty-five minutes. They did an



enormous amount of squirming and riggling showing that the heat and air was very uncomfortable to them. I had to leave them for a few minutes but by 12:35 P. M. four had been killed and five minutes later the fifth one was dead. It took only fifty minutes exposure to kill all.

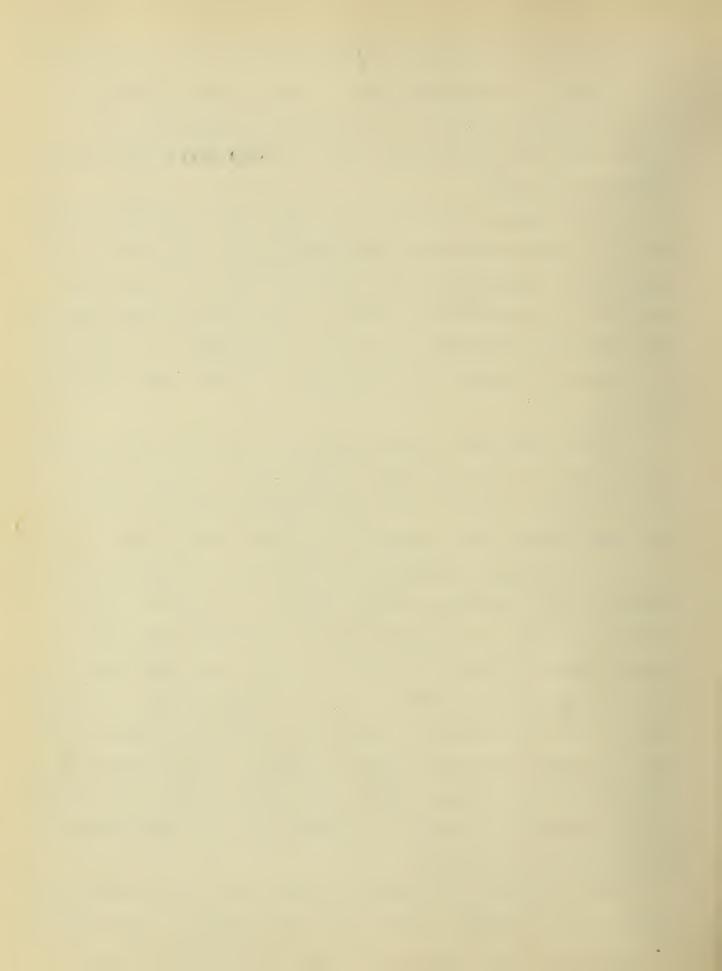
Mature larvae at this date, July 25th, were found in abundance resting in their burrows awaiting transformation into pupae, so it seemed well to ascertain whether exposure would kill them, also.

As soon as the pupae had been killed the larvae were placed upon the same soil, which had become hot and dry by this time, and then left in the sun for results. At the end of ten minutes all of the larvae were dead.

The pan containing the dead pupae and larvae was left exposed to the sun, as in the experiment, until 2:00 P. M. when it was found that both larvae and pupae had completely dried up, leaving shriveled pieces of skin behind to show where they had been.

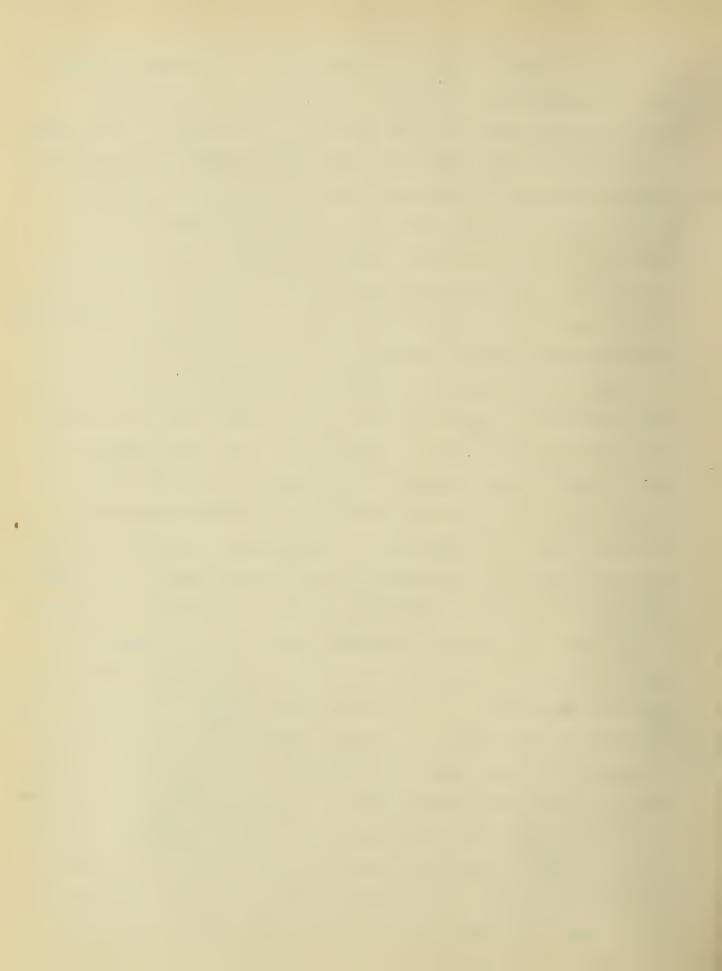
On the evening of August 6th another trial was given plum curculio pupae to see what effect exposure to the damp evening air had upon them. Eleven pupae were placed upon some finely sifted soil and allowed to remain over night. All were alive the next morning, so in order to shade them from the sun, they were covered over with branches of evergreen and then placed out in the sun. At noon, nine were dead and by 1:00 P. M., another had died. The eleventh one was found dead an hour later. Mone of the direct sunlight struck the pupae but the drying out of the soil seemed to be sufficient to kill them.

At 10 o'clock on the morning of August 8th, eleven pupae were placed upon some moist, finely sifted soil and left in the shade of an apple tree. By 7:00 A. M., on August 9th, all but four of



these had disappeared and at the same time the following morning, only two living pupae remained. By 6:30 P. M., on the 10th, these remaining pupae were all dried up. During most of this time the weather had been cloudy and damp, still through some means or another the pupae were made away with. The last half day was rather warm and the sun shown out, so this may account for the death of the last two pupae. As for the cause of the disappearance of the other nine pupae I could see no signs of ants; nor could I discern any footprints of birds. Doubtless some predactous insect had been responsible for their disappearance.

Again, fifteen pupae and four mature larvaewere taken from their burrows and placed upon some finely sifted soil in the shade of an apple tree at 2:30 P. M. August 8th. All were examined at 7:00 o'clock the next morning. The night had been very cool with a heavy dew. All the larvae and ten of the pupae were still living at 7:00 A. M. August 9th. Small pinkish colored ants had evidently killed and had eaten the five missing pupae for they were attacking the larvae at this time and were also feeding on the skin a pupa. An hour and one-half after this note-taking, I came back and watched the progress of the work of destruction which the ants had undertaken. At this time quite an army of ants were gathering for the feast. I watched them for ten minutes as they struggled and worked with their victims and then by means of a few drops of chloroform I settled most of those working about the larvae. At 8:40 A. M. I placed a pupa which had nearly transformed into an imago (in fact it had already shed the pupal skin) in the path of the assembling ants. When the ants first made their attack upon this victim, the latter was able to keep them off by constantly

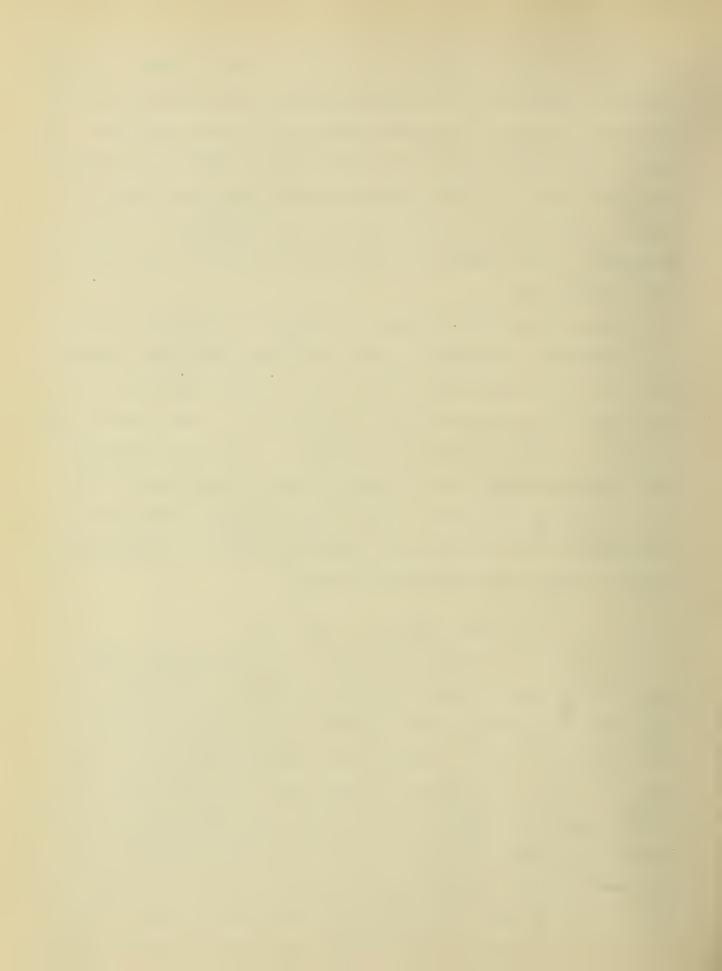


throwing its legs backwards and forwards; soon, however, the ants became too powerful and the immature beetle was killed, serving as one of the courses at the feast which the ants were enjoying. At noon the ants had eaten most of the immature beetle and had killed four more pupae. All the larvae and pupae had been killed and most of them totally destroyed by 6:30 in the evening. This destruction of ten pupae and four larvae was a very good day's work for the ants.

These trials of the effect of exposure of pupae show that anything which unearths the pupae, subjecting them to the influence of the air, sun, ants or predactious insects would aid very materially in exterminating the plum curculio. For a season similar to that of 1903 cultivating orchards to a depth of from 1-1/2 to 2 inches once in every two weeks, from the last week of July to the first of September, at which time the bulk of pupae are in the ground, would, no doubt, be highly beneficial in furthering a ridance of this enemy of orchard fruits.

#### PLACING APPLES IN THE SUN

As a result of another experiment it was incidently shown that the placing of apples, in which larvae were developing, out where the sun shown upon them, proved a very effectual method of destroying the insect. Three lots of apples were used in each case, and after twenty days, a record was made on the number of larvae, pupae and imagos developing from the fruit. In the first instance 200 apples were left in the shade of an apple tree and the record showed 4 apple curculio adults, and the following forms of the plum curculio - 15 larvae, 23 pupae, and 5 imagos; making a total of 43 possible plum curculios and 4 apple curculios develop-



ing to maturity. In the second instance 200 apples were treated in the same manner with a record showing no apple curculios, 9 larváe, 23 pupáe and 2 imagos, of the plum curculio making a total of 34 possible insects. In the third instance, 250 amples were placed in the sun with a record showing 1 larva, 1 pupa, and 1 imago of the plum curculio, only making a total of 3 possible insects. The apples were all gathered at the same time and were placed in a bucket from which they were counted into boxes so arranged that the escape of insects was impossible. (For full description of these boxes see under "Depth of Pupation" p. 37.) While nothing can be positively stated as to the number of possible insects which would have developed in the 250 apples had they not been placed in the sun, yet it is reasonable to suppose that the percentage yield should have been as high as in the other two instances. Figuring on the basis of the larger yielding lot of these two, there should have been 54 plum curculios and 5 apple curculios and on the basis of the smaller, there should have been 42 plum curculios; whereas, through the exposure of fruit to the sun the number was diminished to 3, or over 94 % of the plum curculios and 100 % of the apple curculios had been killed in the former case and over 92% in the latter.

Through the facts presented in this experiment it is shown that a very practical method of ridding an orchard of this pest would be to rake the fallen apples out from under the trees and arranging them in thin layers where sun may have full play upon them. So far as is known now this raking process should be begun with the earliest windfalls and continued up until the middle or the last part of August. This treatment is applicable to both insects, the apple



curculio as well as the plum curculio.

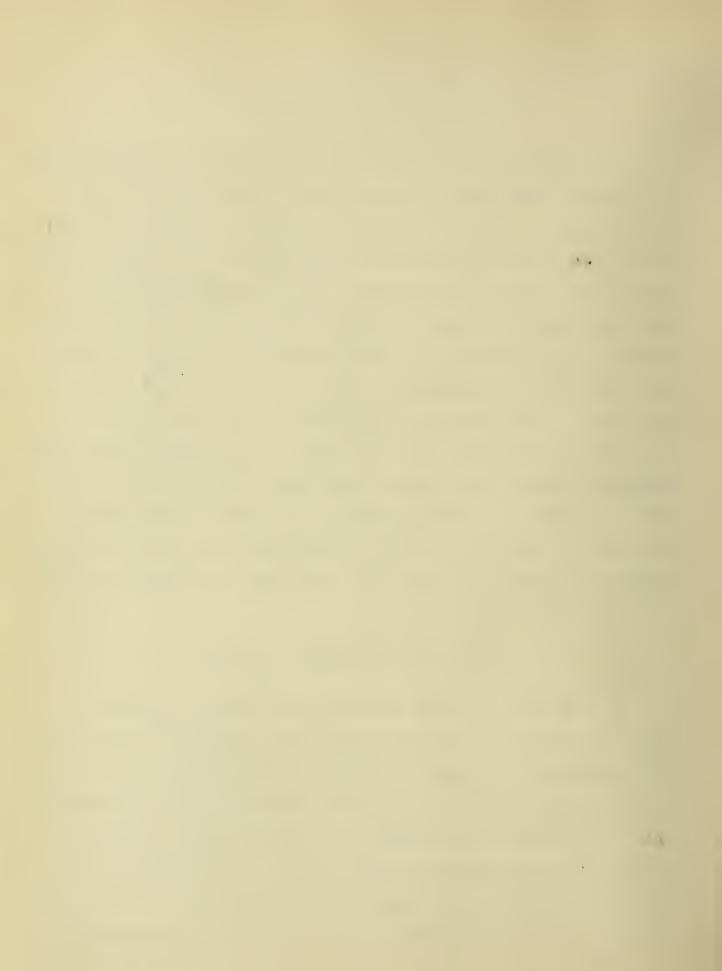
### WILL CHICKENS FAT CURCULIOS?

I had often heard it advocated as a wise plan to set plum trees in a chicken yard, the value being that chickens would destroy the curculios. In order to test the utility of chickens and their capacity as curculio destroyers I threw several of the insects down before some chickens when they came up in the evening for feed.

These were young chickens and evidently had not seen many curculios before. One young cockerel eyed a healthy curculio for a minute and then took it tenderly in his beak as if to taste it before swallowing. Apparently, the first tasted very good for he at once picked up another. By this time, the other hungry young fowls had been convinced that here was something that would help to satisfy their hunger and they greedily pounced upon the remaining curculios. Where it is possible to have chickens underneath trees infested with curculios, they will, no doubt, be of great service in eradicating the pests.

#### JARRING AND CATCHING BY HAND.

The records of jarring curculios which follow in another connection show that this method may serve in helping to kill off the insects but it is such a slow job and the work is done at such a disadvantage with apple trees that the method would be impractical. As for catching by hand, this is still slower and more tedious and less satsifactory than jarring. That they can be caught and should be caught and destroyed goes without saying, but to make a business of trying to get rid of them in this manner would



be absurd.

WORK UPON THE LIFE HISTORIES OF THE CURCULIOS.

Some work was done upon the life history of the two curculios but owing to the season at which most of these investigations were pursued, very few facts were definitely brought out. To gain an accurate conception of the time of development through the egg, larva and pupa stages, would require that the investigator begin his work in the early spring and pursue it very persistently for two or more months. Owing to the time the work was begun nothing was definitely shown as to the actual time required for the eggs to hatch and then for the larvae to pass through their development but some data were secured as to the time of pupation in the case of the plum curculio. While the first two of these transformation periods remained unsolved with the last mentioned insect, all were left obscure in the case of the apple curculio. What little was ascertained regarding the apple curculio was estimated in a roundabout way.

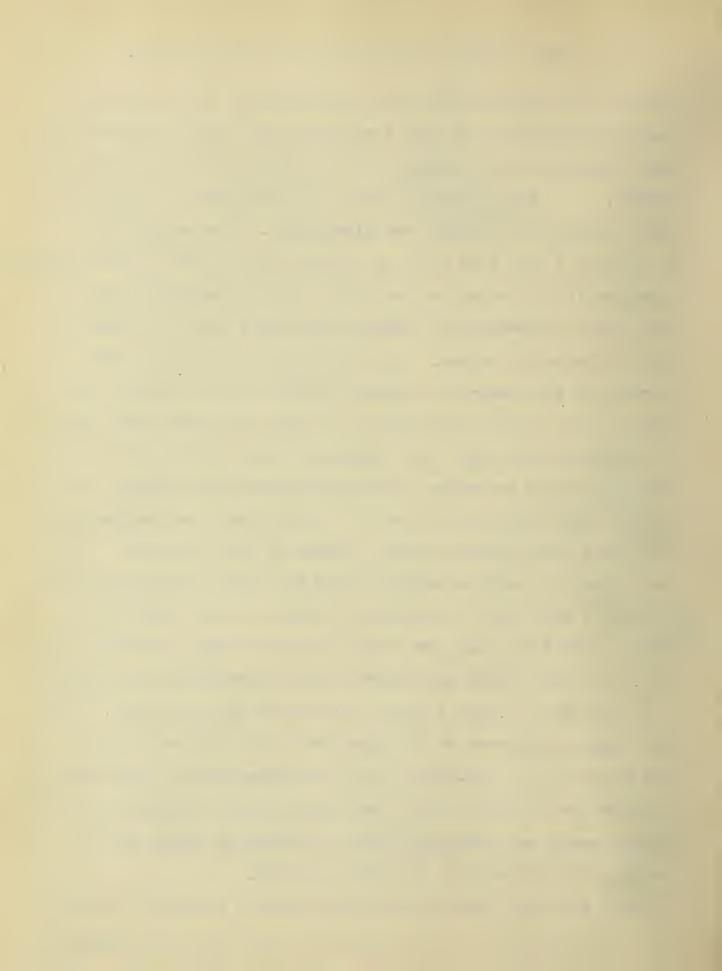


Notes on the Life History of the Plum Curculio.

Mating. - My attention had often been attracted by the pairing of the Plum Curculios, so on July 2 an attempt was made to observe the exact process, for this process is the extreme beginning of the lifehistory. Plum Curculios which I had confined in a glass jar were observed to be mating very plentifully. They seemed to be having such a hard time while in the jar with the other ever-scrambling curculios that in order to give them a better showing, and also to make better observations. I reached down with a stick to which the female immediately seized. By this method the pair, the male clinging to the female, was removed from the jar and brought out where I could observe their antics by means of a small hand lens. In the case of the first pair removed, the male seemed unwilling to have one observe him under such circumstances, soon released his hold on the female and scampered away. Another pair was secured, where the female distinguished herself because of her liveliness. She seemed bound to relieve herself of the male, which clung tenaciously to her. I soon found by placing my finger upon the feet of the female I could hold her just where I pleased without molesting the male. (This male seemed less modest than the preceding one observed).

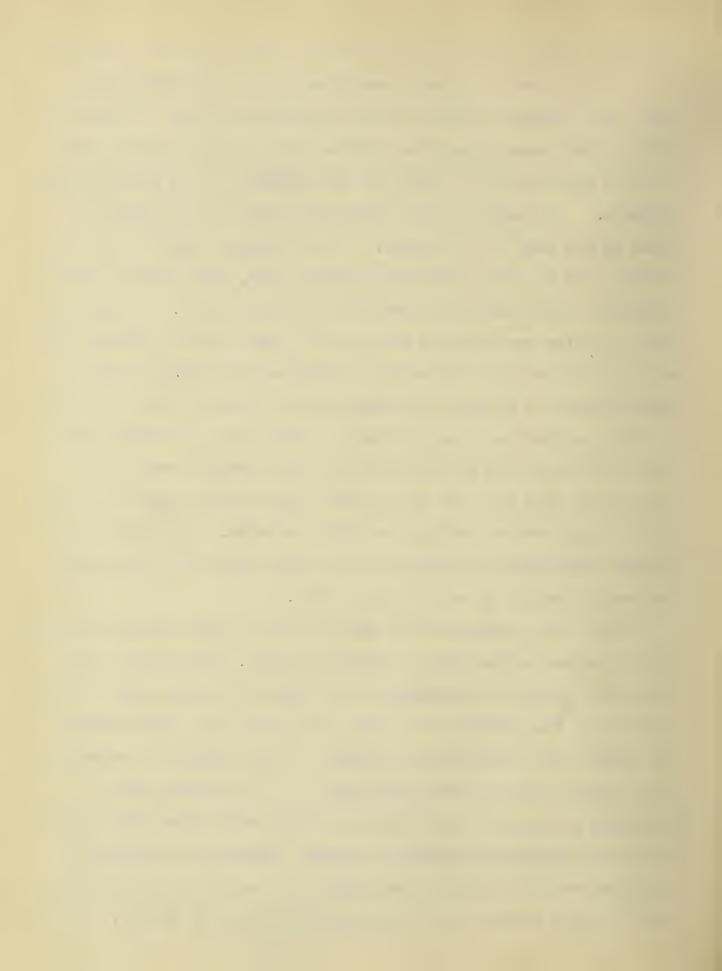
It was 6.05 P.M.when I began observations upon this pair. The male clung to the back of the female with his fore pair of legs fastened over the wing-hinges, with his middle pair of legs clutching her body just in front of her rear legs and with his hind legs fixed tightly around and extending under the abdominal region of the female. In this position the union was made.

During the first part of the mating the male projected his organ very rapidly so that the end tickled the very tip of the female's



abdomen. This seemed to be a tickling process which was indulged in to get the female to lower her abdomen below her wing-covers, which was necessary before the union could take place. When this tickling had accomplished its purpose and the union had been made, the male manipulated his organ by the movement of the rear abdominal By means of his prothoracic legs he held himself in close to the body of the female. This process continued for 20 minutes when the male evidently wanted a rest, which lasted about one minute: he again mounted the female and began teasing. This time when the union was made the female did a great deal of bucking and squirming to get rid of the male. With her hind feet she could easily reach the organ of the male, but he prevented her by the use of his hind feet to cover this part. When the process had once begun the female did not appear uneasy any more, and even when I released my hold upon her she did not run about as before, but stood stamping her feet and wiping one with the other. This second process continued 14 minutes when the male crawled off and began scampering rapidly up and down the stick.

On July 3 two instances were noted where the males used their fore feet in caressing the female before the union. They would draw their feet across the forehead of the female; beginning just at the junction of the proboscis and head. The stroke was made backward and upward with side-sweeping motion. This action was repeated very rapidly when the union was made. In one case this caressing so occupied the attention of the female that she neglected the usual kicking and squirming process. However, in the second instance even with all this caressing the female was dissatisfied, for it rather seemed to be a warning of what was to follow. When



the stroking began, she at once commenced prancing and kicking, but she was not quick enough to rid herself of the male nor of his infliction.

No mating was observed to take place upon the trees, but whenever the curculios were confined, seemingly the first impulse that struck the male was to mate with a female. Much of this mating was observed during the late summer, when it was done by the brood of 1903 which had only lately emerged from the ground.

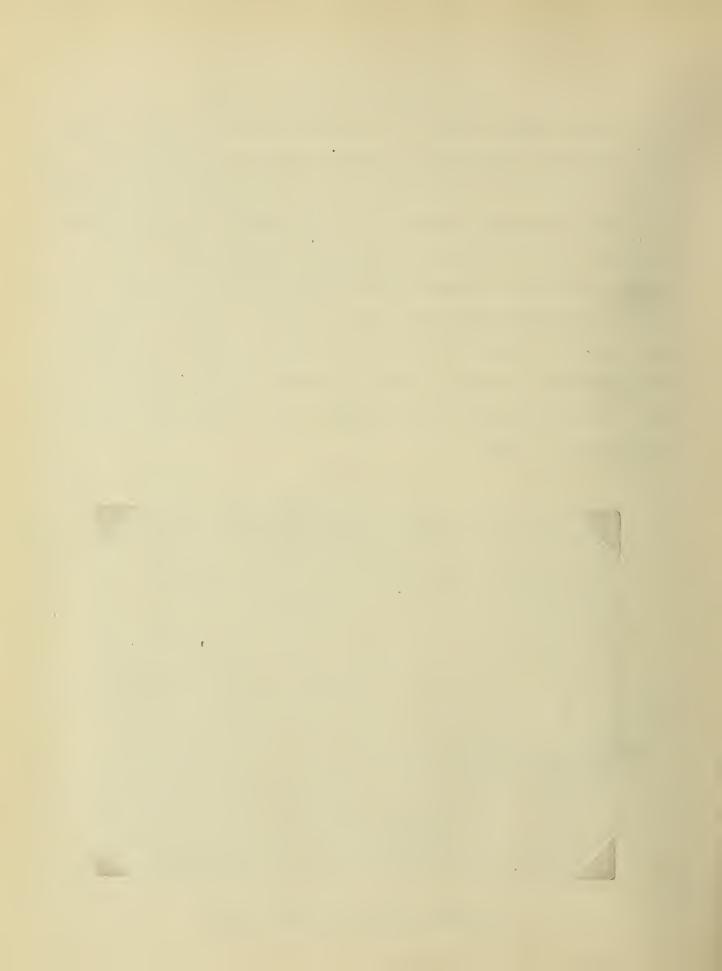


Jars Used as Breeding Cages.

on July 4th some glass fruit-jars covered with lamp chimneys were arranged as prospective breeding cages for the curculios. The jars used were filled with water and over the mouth six thicknesses of cheese-cloth were placed. In each covering of cheese-cloth there was a hole in which a branch could be inserted. When a branch containing an apple had been placed in the covering, a No. 2 lamp chimney was fitted down tightly over all, and the top of it was covered securely with cheese-cloth held in place by a rubber band, after the insects had been deposited within. The accompanying illustration shows these breeding cages as they were when the insects were in them.



Breeding and Observation Cages.

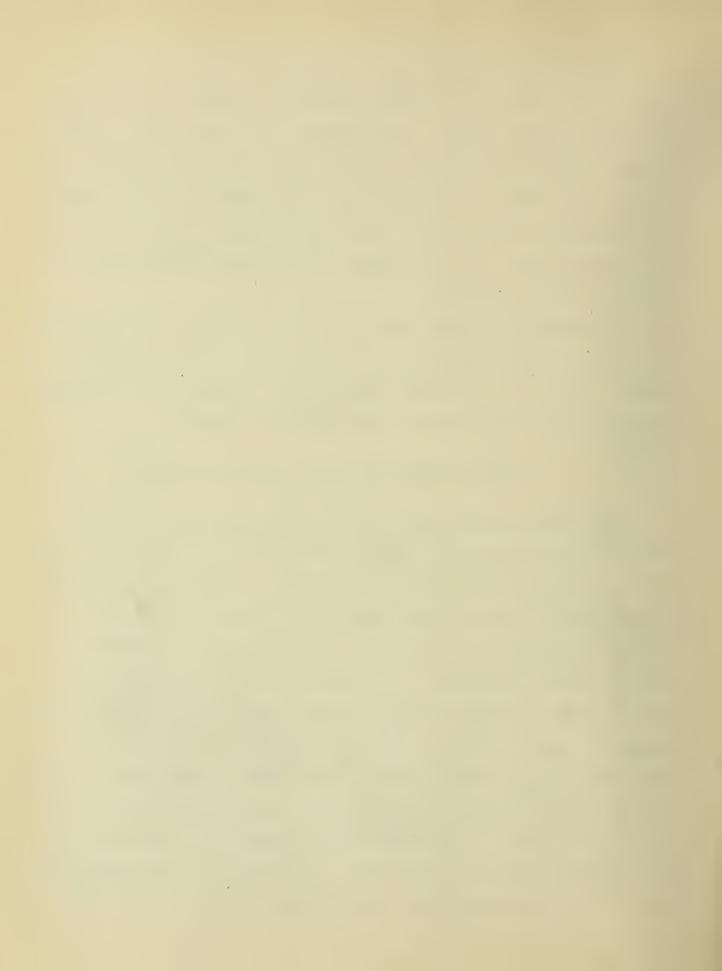


A great many pairs of plum curculios were noticed mating shortly after emerging from the ground and some were then selected for these breeding cages. Regardless of the fact that they were closely observed at times and kept in confinement for several weeks, no eggs were laid although they fed heavily upon the fruit. Some old insects were confined in these cages on July 4th but they did not lay any eggs. It is presumed that the egg-laying season was over for these individuals.

In-as-much as no eggs were laid by the brood of 1903 in apples confined in these cages and also because few eggs were found in apples, later than the period when the new curculios were confined, it seems very probable that there is no second brood.

Length of Egg and Larva Stages Combined.

Professor Grandall confined some plum curculios in a glass vessel in his office with some punctured fruit and found that larvae emerged, as an average, in twenty-six days. This may be a shorter period than is normally found where the apples contain eggs and larvae are exposed to the open air and fluctuating conditions of temperature and moisture. In instances where apples were under controlled conditions the egg and larva period has occupied at least a greater space of time. Where apples were confined in a sand seive and covered securely with cheese-cloth on August 1st, a plum curculio larva emerged on September 7th, representing a period of thrity-seven days. Wild crabs were gathered from a tree on July 30th and confined in a tight box. A plum curculio larva emerged from them on September 10th, representing a period of forty-two days.



## LENGTH OF PUPA PERIOD

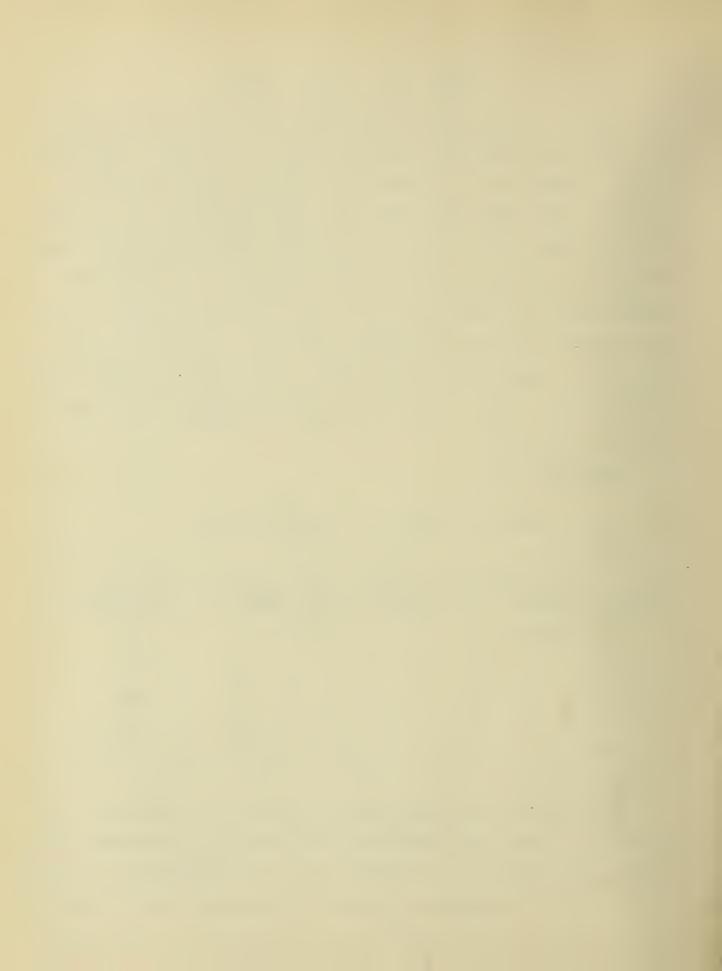
About the middle of July two tiles were placed in the ground and filled and packed with earth leaving a thin layer of loose soil on top. These were so located that they were fully exposed to the sun. Upon July 20th, eight plum curculio larvae were placed in one of these tiles, No. I. The larvae irmediately buried themselves in the loose, soil after which the tops of the tiles were closed over with cheese-cloth which was tied down securely. Ten plum curculio larvae were placed in the other tile, No. II. on July 22nd. Beginning with July 28th, daily observations were made on each of the tiles. The following table shows the dates when the beetles emerged.

PUPATION PERIOD OF PLUM CURCULIOS.

TABLE NO. V.

		A	Date of Emerg- ence	No. Days Pupating
I :	July 20.	2	August 16	27
		1	" 20	31
II :	" 22	1	" 13	22
•		1	" 16	25

On August 27th six plum curculio larvae were placed in a can of earth and when I left Barry for the University on September 12th, it was taken with me. On October 6th, one adult, curculio was taken from the can, representing a period of thrity-nine days for pupating. Four more adult beetles were removed on October 8th, which showed



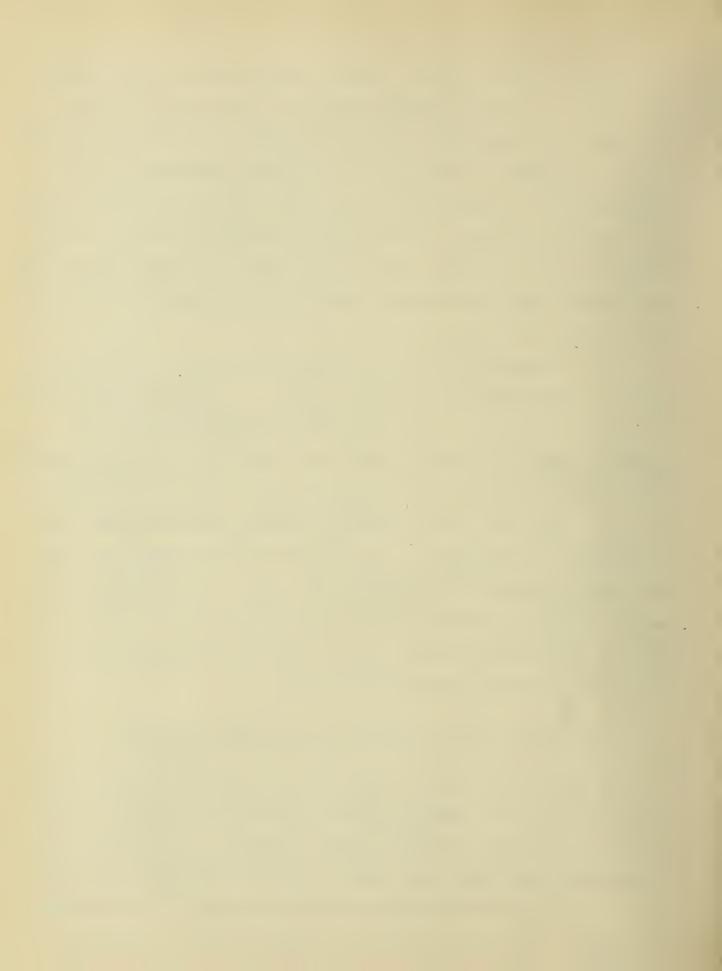
a period of forty-one lays. Careful examination of earth showed no trace of the other curculio either as a larva, pupa or adult.

Here it is seen that the pupation period varies from twenty-two to forty-one days. The heat of the sun may have shortened the length of time required in the case of the tiles and the cool weather to which the others in the can were subjected, may have lengthened the period for them. No doubt but what the figures given here very nearly cover the extremes, either for the shortness or longness of the pupation period.

It is interesting to note the season occupied by the plum curculio in transforming from larva to adult. The first mature beetle
observed emerging by me was found while digging under some plum
trees on August 1; counting twenty-two days from time of entering
ground until it emerged as a beetle, we have pupation beginning on
July 10. The last larva observed to emerge from fruit came from
a wild crab on September 10; counting a period of forty-one days
we have the period ending October 21st. For the bulk of the insects, however, it seems well to predict that, for a season like
that of 1903, they are pupating most abundantly during the last
half of July and the first half of August.

Notes on the Life History of the Apple Curculio.

An attempt was made to redoposit the eggs of the apple curculique after they had been found in a fruit, by making cavities in other fruits and placing the eggs in these cavities. On July 9th two such trials were made. By means of a disecting needle cavities were made in unpunctured apples which were allowed to remain upon the trees. The opening into each cavity was made as small as



chamber. Preliminary to the redopositing, the cavities were dried by swabbing them with pieces of cheese-cloth. The eggs were taken from their original cavities on the point of a disecting needle and allowed to drop into their new, artificial cavities. Apple pulp was then placed into and over the opening so that air might be excluded as much as possible. However, on examining these redeposit fruits by cutting into them on July 19th, the eggs were found to have been destroyed, presumably by rot which infested the cut places.

With the utter failure of this experiment, all hope for obtaining definite information regarding the life history of the apple curculio during the season of 1903, vanished.

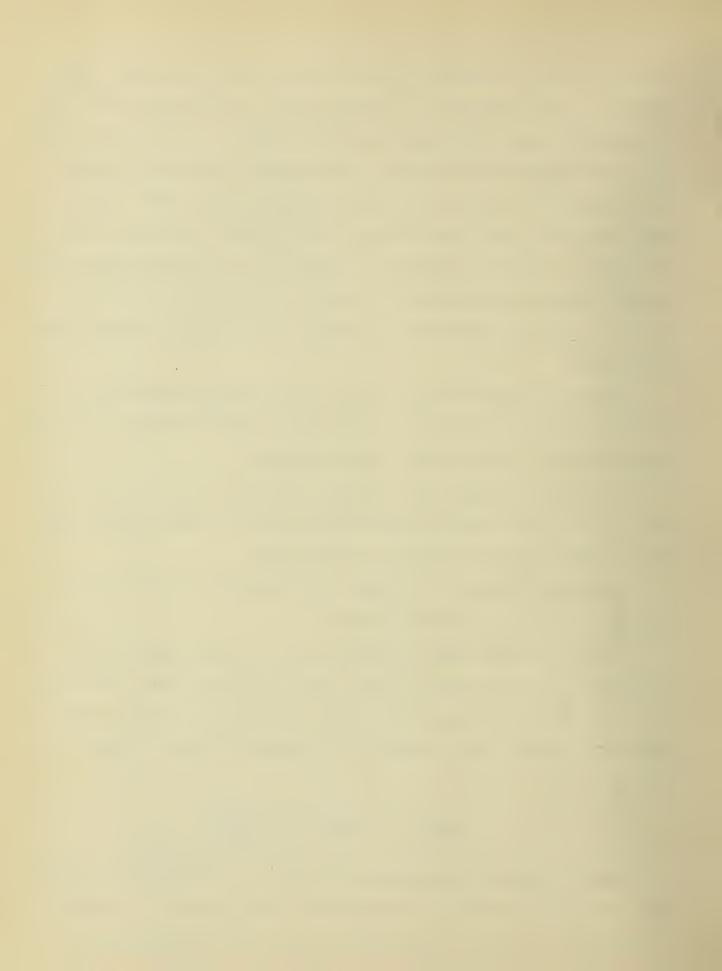
The first emerging apple curculio beetles were noted on July 14th and the last emerging beetle came out in a box of apples some time between September 12th and October 2nd.

Pupating forms of this beetle were found in the fruit most abundantly during the month of July.

Freshly emerged apple curculios were also confined in the breeding cages with apples on July 16th but no eggs were deposited by them although kept confined until September 10th, which fact seems to indicate that no second brood occurs during a single season.

## HABITS OF THE CURCULIO.

Quite a little information was gained in various ways regarding some of the habits of the insects; but at best it is only fragmentary and needs to be supplemented by more extended and



detailed work.

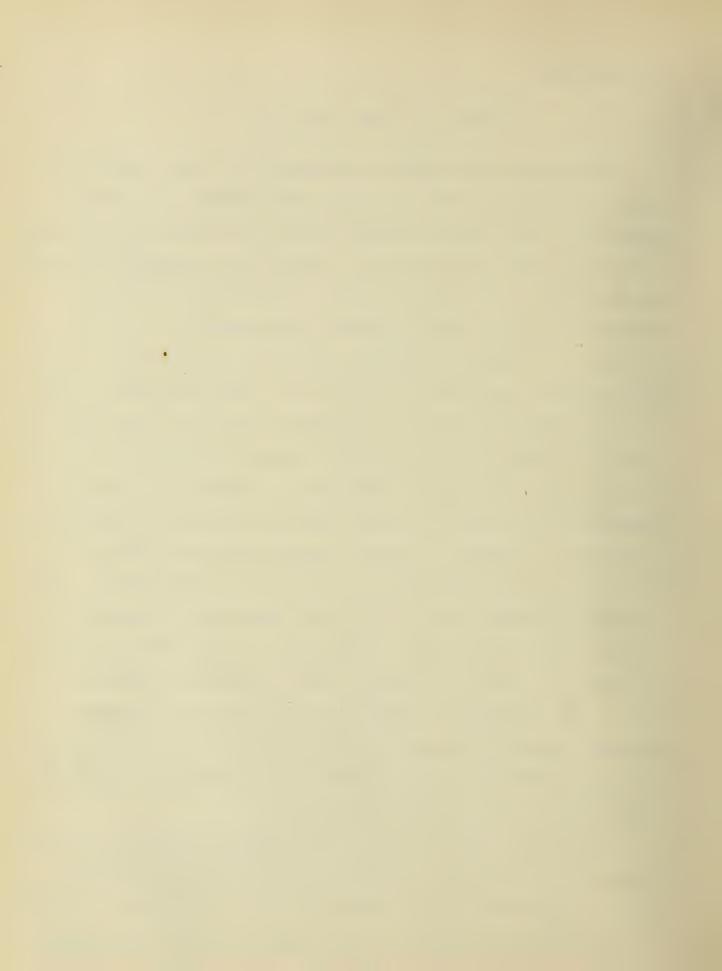
#### HABITS OF PLUM CURCULIO.

ics

Probably the most notable evidences that a plum curculio has visited an apple or plum are the so called cresent and feeding punctures. The cresent punctures usually accompany egg-laying and consist of a small egg-slit with a cresent cut extending about half way around it. I did not have the opportunity of seeing one of these cuts made so I cannot describe the process.

with the feeding punctures, definite notes were taken, or the exact process on July 6th at the time they were being made. The feeding puncture is started by the curculic eating a small round hole in the skin of the apple; and I noted no case in which in the starting process the skin was not eaten. Gradually the hole is deepened and the orifice enlarged until it is usually about 1/16 of an inch in diameter. However, in some instances during the later work it has been observed to be 1/4 of an inch across. The enlarging is accomplished by the insect swinging its proboscis from one side to the other. As a result of this last process the hole is left either in a cresent, ovate, circular or irregular shape. In deepening the cavity the curculic pushes its beak downward gradually working it back in under its body until at last the insect appears standing on its head in order to get the flesh from as far on the interior as possible.

In the late work during the heated days of August and September it was not uncommon to find the plum curculios established within cavities made in the apples and there would either be feeding "to their heart's content" or else sleeping with the head hanging



over the margin of their den in much the same manner as an old watch-dog sleeps in his kennel. A record of the occurrence of plum curculios found in cavities was begun on August 21st and the following table shows the data collected.

TABLE NO. VI.

FINDING OF PLUM CURCULIOS UPON APPLES DURING THE LATE

SUMMER

Dat	е	: : No. on surface :	: No. in cavities
August	21	14	25
17	22	3	11
17	26	8	8
17	28	28	3
11	31	20	6
Sept.	12	:	3
Oct.	1	:	4
19	2	5 :	12

Upon several occations fruit was examined to ascertain the number and kind of punctures upon the surface, whether eggs were laid, whether larvae had developed and in what condition the larvae were found. All of these records were made early in July and the following table shows what was found relating to the plum curculio.

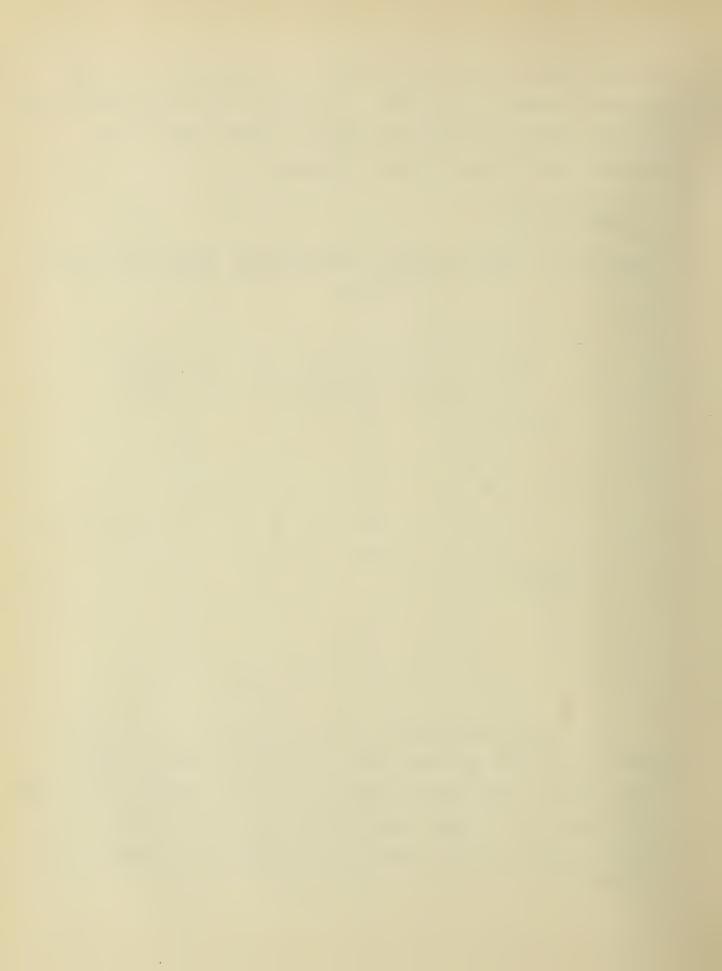


TABLE NO. VII.

EXAMINATION OF APPLES FOR PLUM CURCULIO PUNCTURES,

LARVAE, ETC.

No. of Apple	: :No. Feed-	No. Egg	No.	Eggs:	No.	liv-	No.	larvae in burrows
25,772.20	:Punctures:	Punctures			váe			
	•						•	
1	: 22	1 :		:			•	1
2	: 4	1 2 2		:			•	2
3	: 3			:		1	•	1
4	•	3 :					:	
5	: 4			:			•	
6	: 4	1 :				1	•	
7							•	
8 9	9 : 1						• •	
10	. 6		•		•		•	
11	i		•	•			o	
12	ī	2		:		1	•	1
13	: 4	1					•	1
14	: 8 :	: 1 :	•	:			•	1
15	: 1 :			:			e 6	
16	: 3 :	: 1 :		:			•	1
17	6	1.		:			•	1
18	: 13	1 2		:		0	•	
19 20		2		•		2	•	2
21	5	î î	•				•	A
22	: 1	. 4	•	•			•	
23	9	1		:		1	•	
24	5	2				1	•	
25	: 1 :	2 2		:			•	
26	: 5 :	2 :					:	
27	: *	4		:		1	•	
28	: 3 :	3 :		•			•	
29				:			•	
30 23	: 2 : 6	2					•	
31 32	: 11	3					•	
32 33	: 38	3 2	2	•			•	
		~ ~	~	•			•	

In an exampnation of 195 fallen apples, made on July 16, I found 38 plum corculio larvae and one fruit in which a larva had



been. No record was made upon the exact number of punctures. In one of these apples two plum curculio larvae were found. The following photograph is illustrative of the early work of the plum curculio upon young apples.

Picture No. 2 on p. 6
shows the feeding work of
the plum curculio very nicely, also. These punctures
are more characteristic of
the late feeding.

The early feeding and cresent punctures cause deformed, gnarly apples, while the late feeding punctures cause blemishes in the form of holes which destroy the salableness of the fruit.

Furthermore, through the

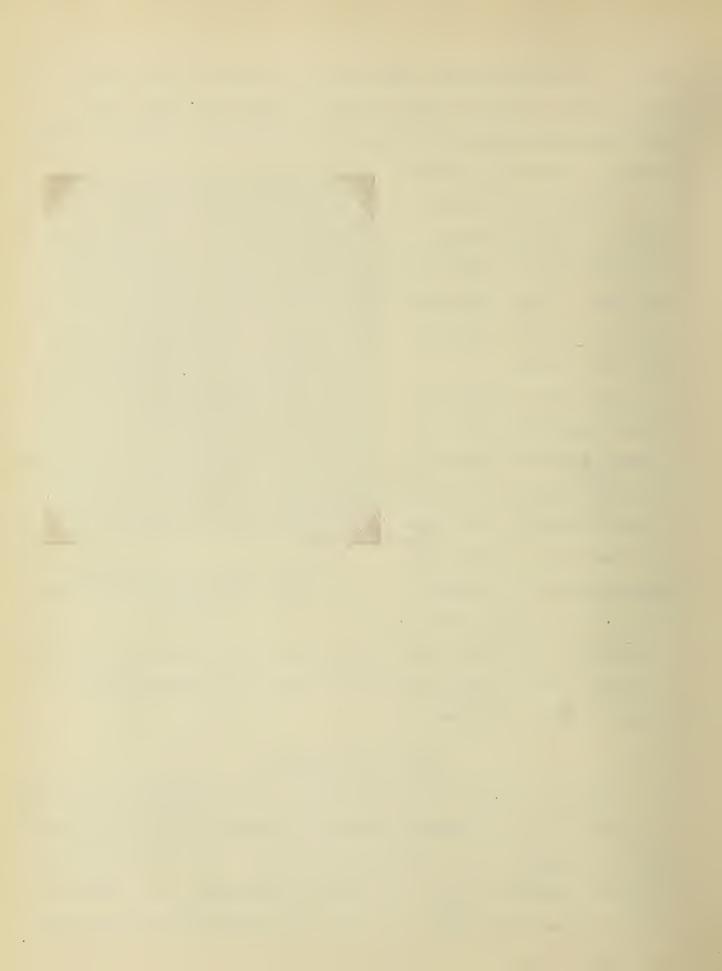


A Fruit Showing the Results of Early Feeding Work of the Plum Curculio.

development of the egg, which is laid in connection with cresents, into the larva which burrows in the fruit, premature falling is caused in most instances.

## Depth of Pupation.

The depth at which plum curculio larvae go beneath the surface to pupate has been variously stated and supposed authorities usually give the depth at from three to six inches. In order to get some definite information upon this point I dug pupae upon a number of occa sions,—in most instances using a foot ruler and making exact



measurements of the depth. At other times measurements were made by the use of the eye alone. Considerable work was carried on under some plum trees, the fruit of which had nearly all fallen from the trees as a result of the development of plum curculio larvae in them. Occas ionally I dug for pupae under apple trees but as the apple crop was very short the ground was not very plentifully supplied with them; so most of my attention was confined to the plum trees.

Two principal methods were used in digging up the pupae and ascertaining their depth below the surface; first, blocks of soil were removed by the use of a spade, and, by using a case-knife thin slices were shaved off until the pupae were located; and second, a hole from six to eight inches in depth was dug by means of a spade and this was gradually enlarged by cutting thin slices from the sides with a case-knife. In practically every instance the examination of the soil took place to a depth of three or more inches.

The following table shows the record of this work which was begun on July 24th and did not stop until September 11th.

TABLE NO. VIII.

DEPTH AT WHICH PLUM CURCULIO LARVAE GO TO PUPATE.

Dat	е	: : No.	found	•	Form	: Depth in inches.
July	24 28 30		6 3 1	a a a	Pupal	Between 3/4 and 2 : 3/4 : 1-1/2
Aug.	1	•	1 2 3	0 0	Larval " Pupal	1/4 : 1 1/2

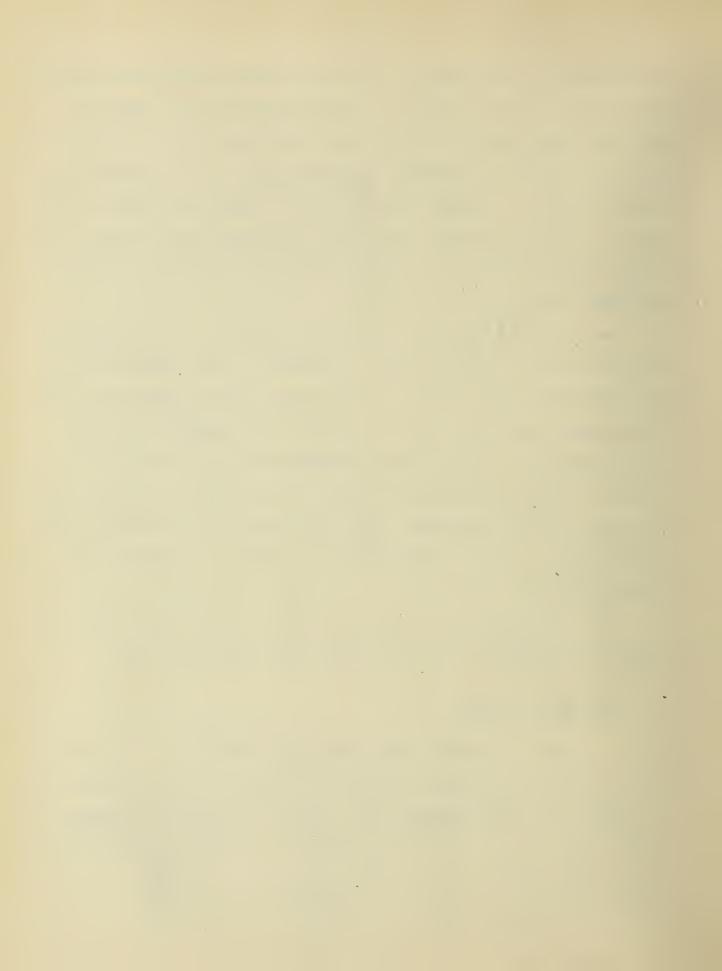
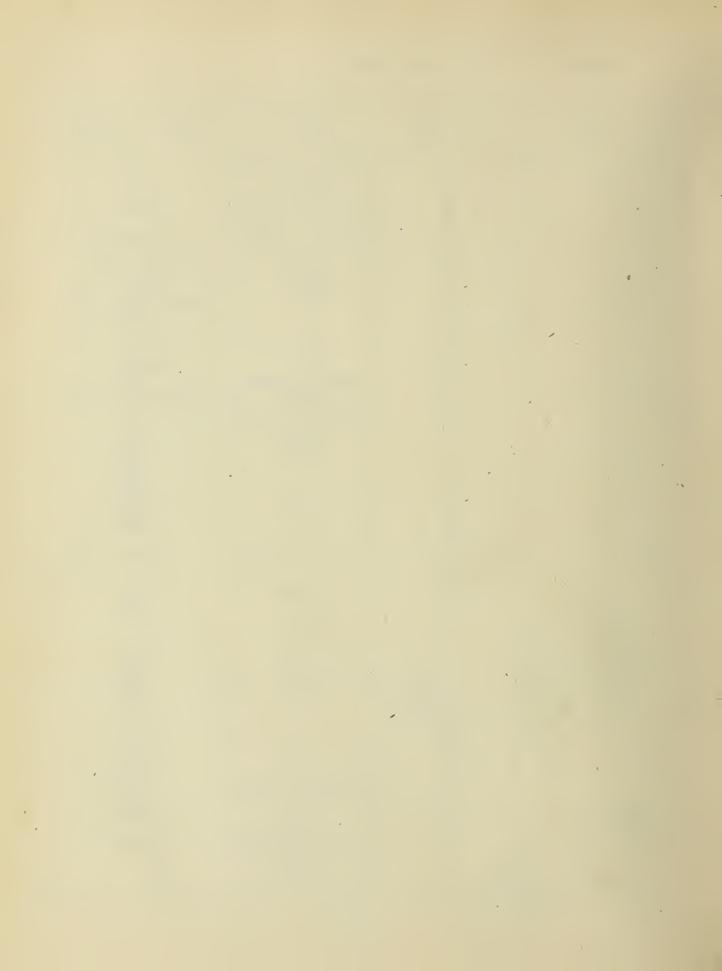


TABLE NO. VIII. (continued)

Dat	te	No. found	Form	Depth in inches
Aug.	1		Pupal " " Immature imago " "	3/4 1 1-1/2 1 1-1/4
. 3		2 2 1 1	" " Larval Pupal "	Not over 2 1 1-1/4 Not over 1-1/2
17	5	: 1 : 2 : 1 : 2	11 11 11 11 11 11 11 11 11 11 11 11 11	$\frac{1/2}{3/4}$ 1 1-1/2
17	6	: 1 : 2 : 9 : 10 : 3	: Immature imago : Pupal : Irmature imago : Pupal	Not over 1-1/2
***	7	: 1 8 5 : 1 : 11 : 8 : 3 : 3	Larval  " " Pupal  " Immature imago	1/4 1/2 3/4 1-1/4 1/2 3/4 1
ŦŸ	8	2 4 2 1 1 3 7 5 4 3 1 2 2 2 2	Larval  ""  "Pupal  ""  ""  ""  ""  ""  Immature imago	1/4 1/2 3/4  1 1-1/2 1/4 1/3 3/4  1 1-1/4 1-1/2 1-3/4 3/4
Sept.	7	: 2 2 2 2	Pupal  Immature image	1-1/2 1/2 1 1/3
11 ]	11	1	: Pupal	1



In all there are 153 records on different individuals ranging in depth from 1/4 to 2 inches (more exactly 1-3/4 inches).

DEPTH OF AS REGULATED BY TILTH OF SOIL

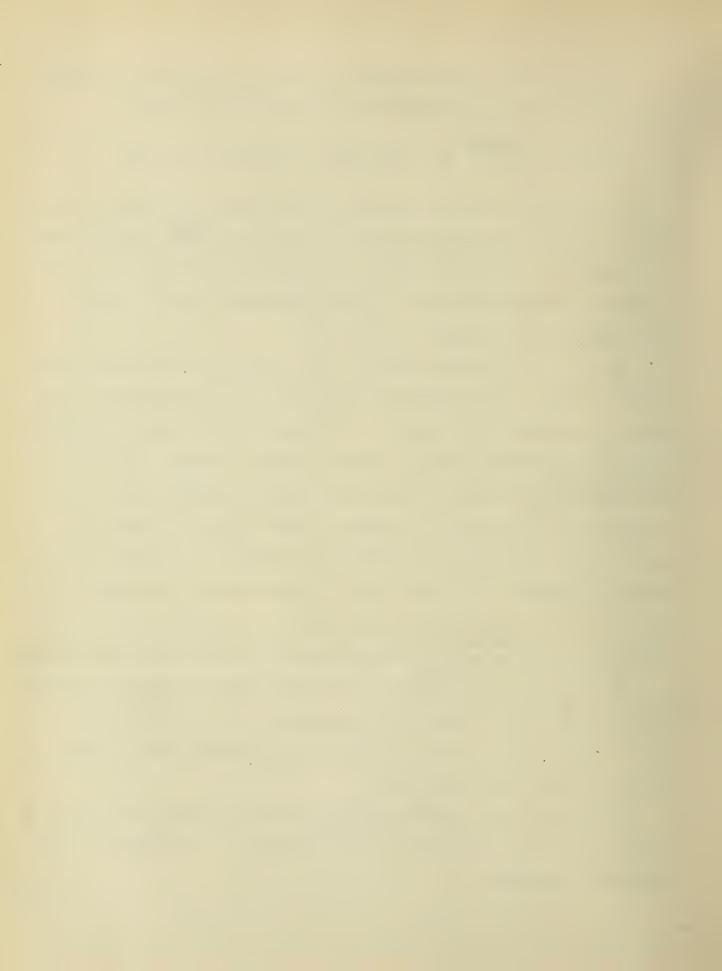
An effort was made to get some information as to whether looseness of the soil had anything to do with the depth to which larvae go to pupate. For this purpose three bottomless boxes 10" X 12" X 14" were prepared for what I called "pupation boxes". These were placed in the ground on July 20th.

Box No. 1 was placed under an apple tree where there had been no cultivation, and consequently there was a good matting of blue-grass sod covering the ground. I dug away on all sides of a space about this sod-area leaving a cubical block of earth. When this had become small enough, through shaving slices off of the sides, I placed the box over it and drove it down tightly so that only a few inches of the top part of the box projected above the ground. Around the edges of the box, where it did not fit tightly up to the soil, dirt was tamped in tightly so that as a whole the ground was condition. primarily in the same as it would have been under normal circumstances.

Box No. II was placed in a cultivated field where the sunlight could strike it, the earth being enclosed as in the case of Box No. I; while Box No. III was placed in the ground under an apple tree and filled with loose dirt.

Soil was packed tightly around the outer edges of the boxes in each case, so there would be no drying out and cracking of the soil they contained.

Apples had been gathered from beneath the Grimes Golden and Ben Davis trees which had every indication of containing larvae of



the curculios. In Box No. I, 200 Grimes Golden apples were placed; 250 Grimes Golden were placed in Box No. II; and 200 Ben Davis in Box No. III. Over the top of each box a cheese-cloth covering was tacked closely to prevent the escape of any beetles which might emerge. Every precaution was taken to see that the boxes were thoroughly curculio tight. There had been no fruit on these trees so that it was not possible that forms of the plum curculio were already in the ground over which Boxes No. I and II were placed.

Upon taking up these supation boxes on August 7th and 8th the following records were made.

Box No. I-gave four adult apple curculios and one adult plum curculio and the following forms of the plum curculios in the ground:

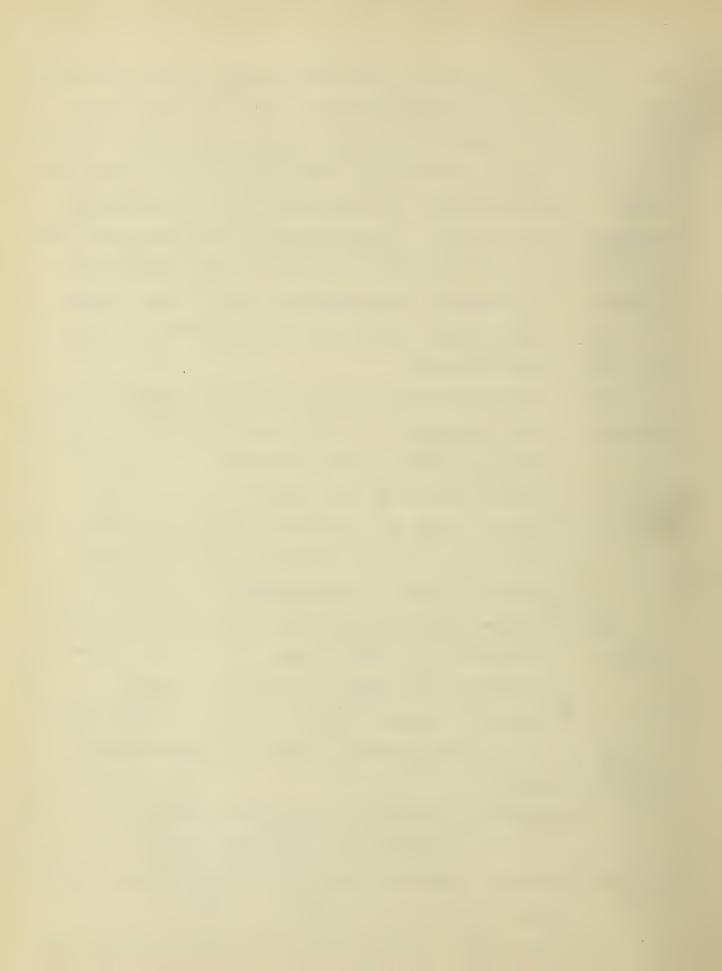
- 1 larva at a depth of 1/4 of an inch,
- 8 larvae and 11 pupae at a depth of 1/2 of an inch.
- 5 larvae, 8 pupae and 1 immature beetle at a depth of 3/4"
- 4 pupae and 3 immature beetles at a depth of 1 inch.
- l larva at a depth of 1-1/4 inches.

Box No. II gave the following forms of plum curculios in the ground with nothing whatever above ground.

- 1 larva burrowing down at a depth of 1/2 inch.
- 1 pupa and 1 immature beetle at a depth of 1-1/2 inches.

Box No. III gave nothing above ground with the following below the surface -

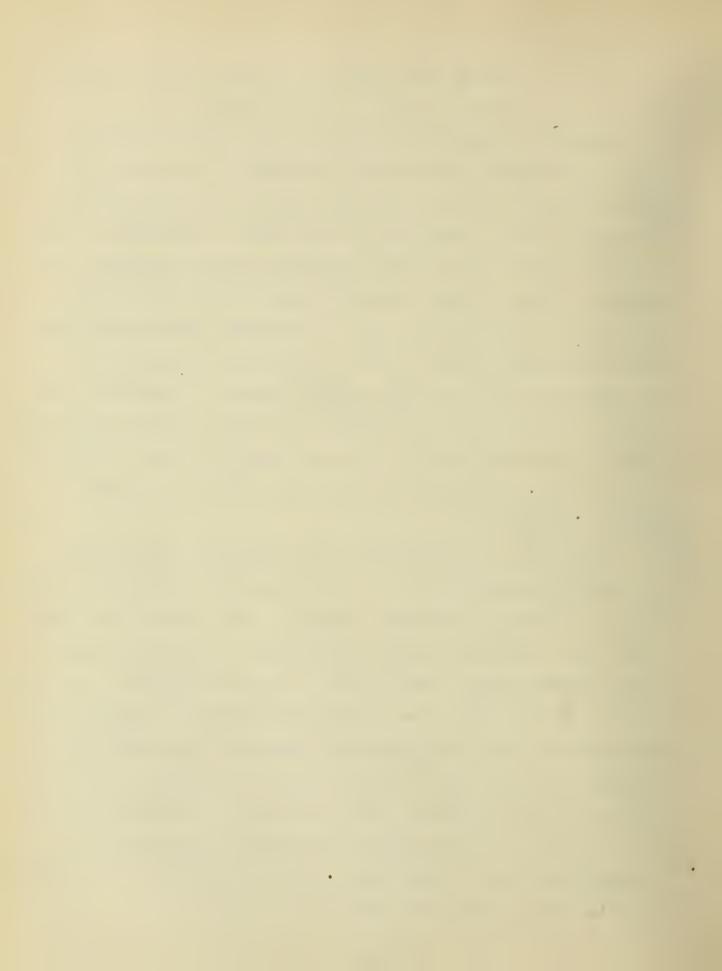
- 2 larvae and 1 pupa at a depth of 1/4 inch.
- 4 larvae and 2 pupae at a depth of 1/2 inch.
- 1 larva, 7 pupae and 1 immature beetle at a depth of 3/4"
- 1 larva and 6 pupae at a depth of 1 inch.
- 4 pupae and 1 immature beetle at a depth of 1-1/4 inches.



1 larva and 2 pupae at a depth of 1-1/2 inches. 1 pupa at a depth of 1-3/4 inches.

Regardless of the first intention of the author to make a comparison between results secured in boxes No. 1 and 2 on the basis of condition of soil affecting depth of pupation it does not seem well to make a comparison on that score. The effect of the sun was a factor which was not considered when the experiment was planned. As has already been mentioned, the sun's heat played an important part in causing a small percentage yield of plum curculios from these apples, so too, it seems very evident that it depth has played some part in determining of pupation. Doubtless, the larvae which did not to burrow went to the depth of one and one-half inches to get below the dry soil and to escape the heat of the sun. Plum curculio larvae dislike dry soil and they also use every effort to avoid heat.

Considering that these reasons are sufficient for dropping the results secured in Box No. 2 from a comparison of tilth of soil as affecting depth of pupation, boxes No. I and III are still left. These boxes were subjected to the same kind of treatment as regards exposure, shade, sunlight, etc., and only differed in the condition of the soil. For the sake of comparison, the average depth at which the larvae, pupae and immature boetles were found in each box may be taken. This average with Box No. I is .655 of an inch and with Box No. III, .662 of an inch. The difference is so slight that it is not worth consideration and indicates that tilth of soil, other things being equal, has no influence upon the depth to which larvae go for pupation.



# HOW EARLY IN THE DAY ARE CURCULIOS FOUND UPON THE FRUIT?

An effort was made to ascertain whether or not curculios were found u on the fruit early in the morning. On June 30th, I examined some trees at 6:00 A. M. and soon found a plum curculio upon an apple. I plucked the apple and observed the curculio closely for an hour but it did not attempt to do any feeding. It had apparently rested upon a tree during the night for there were no signs of its feeding. On July 1st, at 5:30 A. M., I secured six plum curculios by shaking a small tree. On September 12th, between 4:45 and 5:15 A. M., three curcul os were found resting in cavities where they had doubtless passed the night. At this time the day was just breaking and from the contented manner shown by the insects they had not yet begun work upon the fruit.

#### WHAT PERCENT OF FALLEN FRUIT PRODUCE CURCULIOS.

On August 1st an experiment was started in order to determine the number of plum curculio larvae and apple curculio adults that would emerge from a quantity of fruit. Accordingly the fallen apples were gathered from under twenty-eight Grimes Golden trees, comprising 1200 apples in all. One-half of these were placed in a circular sand seive and covered over securely with a piece of cheese-cloth. After this the seive, containing the apples was placed upon a piece of paper so that all larvae dropping down through the meshes could not escape.

The following record was made showing the number of curculio larvae and adults secured.

From the 1200 amples, which were left in buckets over Sunday,



11 plum curculio larvae were secured so it is well to count 6 for the 600 placed in the seive.

TAPLE NO. IX

PLUM CURCULIO LARVAE AND APPLE CURCULIO ADULTS FROM

600 APPLES - 14 TREES.

Date of Record	: No. plum curculio lar- vae.	No. Apple Curculio Adults.
August 3	6 6	1
5 6 7	: 4 : 2 : 1	1
8 9 11	1	1
12 18 21	: 2 : 1 : 4	1
25 29	2 2	1
31 Sept. 3 7	:	• • •
Totals	34 :	7

It would be impossible to say how many larvae and adults emerged before the fruit was placed in the seive but in all probability the number would far exceed that shown here. These records, when the probabilities of previous developments are considered, serve to impress the fact that the number of curculios developing from an acre of fifty trees would be quite large.



#### DOES LIGHT ATTRACT CURCULIOS?

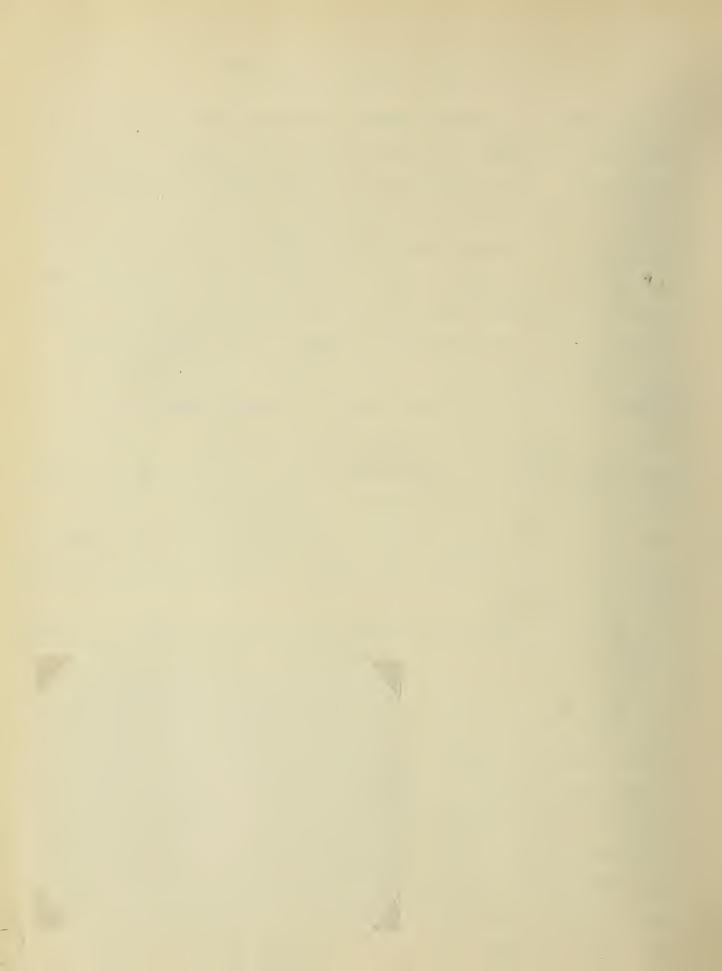
In order to ascertain whether curculios flew at night or were attracted by a light, two trap lanterns were prepared and used in the orchard. In the preparation of these traps two galvanized iron wash-tubs were secured and to the inside, very near the top, sheets of tin, 18 X 30 inches, were riveted making a semicircular reflector. Holes were made through the margins of the reflector, thus made, in which wires were fastened for supporting lanterns. The common lanterns thus supported were hung in the concavity about eight inches from the tin. When the lanterns were lighted the bright curved surface of the tin made a powerful reflector and could be seen for quite a distance on a dark night. Moreover, the smooth surface of the tin made a very effective barier against which flying insects would strike and be precipitated into the tub below. About two gallons of water and one pint of kerosene were placed in each tub for the purpose of killing all insects which fell into thom hem.

Below is a photograph of one of the tubs taken where it remained curing the test.

These trap lanterns
were placed in dead trees,
one at about the heighth
of five feet and the
other was twelve feet or
more above ground. In
this position the lanterns
were lighted on July 4th,
7th, 17th, and 19th.



A Lantern Trap in Position.



on July 24th, the lantern highest up was removed to the ground and placed under a Grimes Colden tree heavily loaded with fruit, where it was lighted at night. Not a curculio was caught in the tubs when the lanterns were lighted. Yet on the afternoon of July 25th I discovered an apple curculio which had possibly fallen from the tree into the tub on the ground. The trial of these trap lanterns indicate that curculios do not fly at night or else they are not attracted by the light.

CURCULIOS FOUND UPON A SHEET PLACED UNDER A THEE
DURING THE NIGHT.

A large sheet containing sixty-six square yards of muslin was spread under trees heavily sprayed with a mixture of one pound Paris green and ten pounds lime to fifty gallons of water on July 10th; the object being to see if any curculios were poisoned. The sheet was visited each morning and evening for a number of days and a record made of findings. On the morning of July 11th two ample curculios were found upon the sheet. They were living and had no indications of being poisoned. Three living plum curculios were found on the sheet at 8:00 A. M. July 14th. While on July 22nd and 23rd two plum curculios and 1 plum curculio were found respectively upon the sheet. Future visits failed to return any curculios. During all this time not a single curculio was found dead, but it seemed apparent that it was customary for the curculios to drop to the ground over night.

SHAKING CURCULIOS UPON A SHEET.

The work of jarring or shaking curculios from the apple trees



began on June 30th and continued at various intervals during my stay at Barry. Collecting the curculios in this manner served a twofold purpose. First, it showed at what time of the day the curculios were the most abundant and second, at what season the insects were found in greatest numbers. No record was kept upon the number of curculios secured from individual trees during the first two days of shaking but from most of them, several (in certain instances 13 or 14) plum curculios and one or two apple curculios were shaken. During the work on June 30th most of the catching was accomplished before 4:00 P. M. At 4:30 o'clock in the afternoon the findings were so limited that operations were suspended for the day. During July 1st I noted that in the early portion of the day about as many apple curculios were secured as there were plum curculios but gradually as the heat of the day increased the latter began to be far in excess. The following table gives the record for remaining shakings, shows dates of shaking and number of curculios secured, and also, the time of day when the work was done.

TABLE NO. X.

CATCHING CURCULIOS BY SHAKING.

Date	: No. tree:	: s:Time of Day	No. apple Cur- culios	
June 30 July 13		2:00 P.M. 9:00 A.M. 9:10 A.M. 9:30 A.M.	. 4 . 1 . 4	11 4 24 30 23
21	: 1 : 1 : 1	7:30 A.M. 7:40 A.M. 7:50 A.M.	• • • • • • • • • • • • • • • • • • •	5 11 9

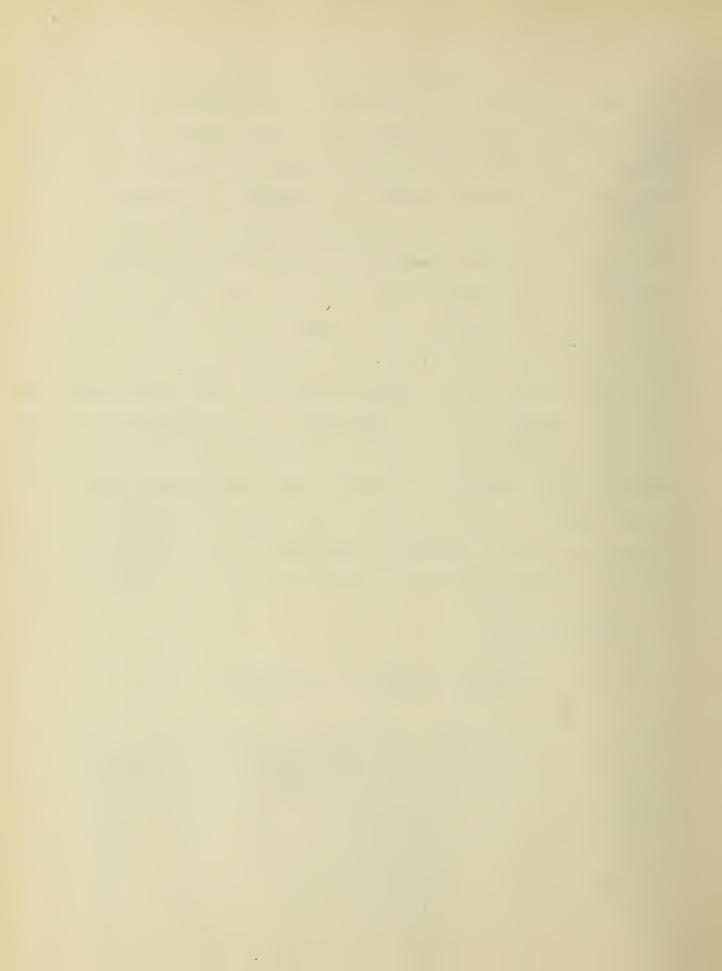


TABLE NO. X. (continued)

Date	No.	trees		o. plum cur- culios
August	1:	1	8:10 A.M.: 7:00 A.M.: 7:10 A.M.: 2	2 1 4 1
n g	30:	1 1 1 1 1 1	7:45 A.M.: 8:00 A.M.: 8:30 A.M.: 4:00 P.M.: 4:30 P.M.: 5:00 P.M.:	2 3 4 9 1 3
	•	J	J.JU 1.14	A.

#### CATCHING PLUM CURCULIOS ON FLY PAPER.

When Professor Crandall visited Barry on July 9th, he conceived the idea that if curculios flew at night they would be caught by hanging tangle-foot fly paper in the trees of evenings and then examining them early the following morning. Consequently, on the evening of July 10th six double sheets of fly-paper were suspended in the trees where they remained until August 10th when they were replaced by fresh papers.

### TABLE NO. XI.

CURCULIOS CAUGHT BY FLY PAPERS

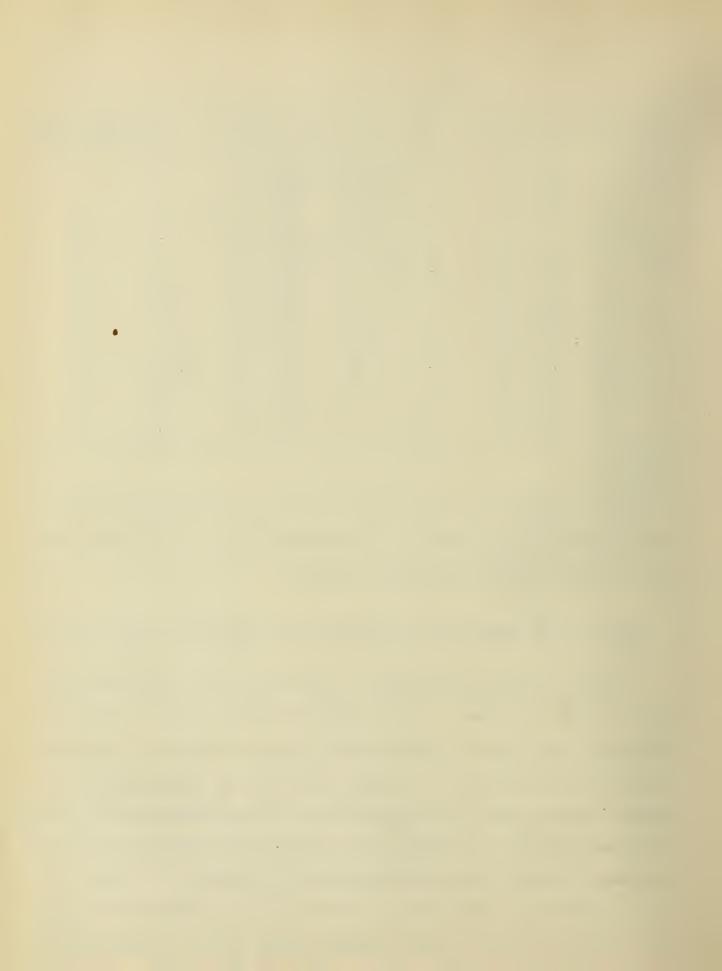


July 10, 7:00 P.M.  " 11, 7:00 " " 12, 7:20 "  " 16, 7:00 " " 17, 7:30 " 1  " 25, 8:00 A.M. " 29, (not given) 9  " 29, " 30, 10:00 A.M. 10  Aug. 3, 8:00 A.M. Aug. 4, 11:00 A.M. 5  " 4, 8:00 A.M. " 5, 9:00 A.M. 7  " 5, 9:00 A.M. " 6, 7:30 A.M. 7  " 6, 7:30 A.M. " 7, 8:45 A.M. 11  " 6, 7:30 A.M. " 12, 8:45 A.M. 1  " 11, 8:45 A.M. " 12, 8:45 A.M. 1  " 15, 8:45 A.M. " 17, 8:45 A.M. 1  " 17, 8:45 A.M. " 21, 8:45 A.M. 9  " 20, 6:30 P.M. " 21, 8:00 A.M. 9  " 32, 8:45 A.M. " 23, 8:00 A.M. 9  " 33, 8:00 A.M. " 24, 6:30 A.M. 1  " 38, 8:00 A.M. " 29, 12:00 M. 5	Prev:	ious	exami	nation	: :	ate	and ·	time exa	mined	o. plum cur- culios caught
Dog Love of Control of	Aus.  or  or  or  or  or  or  or  or  or  o	11, 16, 25, 29, 3, 4, 5, 6, 11, 15, 17, 20, 22, 23,	7:00 7:00 8:00 8:00 9:00 7:30 8:45 8:45 8:45 8:45 8:45 8:00	A.M. A.M. A.M. A.M. A.M. A.M. A.M. A.M.		Aug.	12, 17, 29, 30, 4, 5, 6, 7, 12, 17, 18, 21, 23, 24, 29,	7:20 7:30 (not 10:00 11:00 9:00 7:30 8:45 8:45 8:45 8:45 8:00 8:00	" " " " " " " " " " " " " " " " " " "	1 9 10 5 7 11 1 1 8 3 9 2

These data are not sufficient for any conclusions but they seem to indicate that most of the curculios do not go on the trees at night but fly up in the early morning.

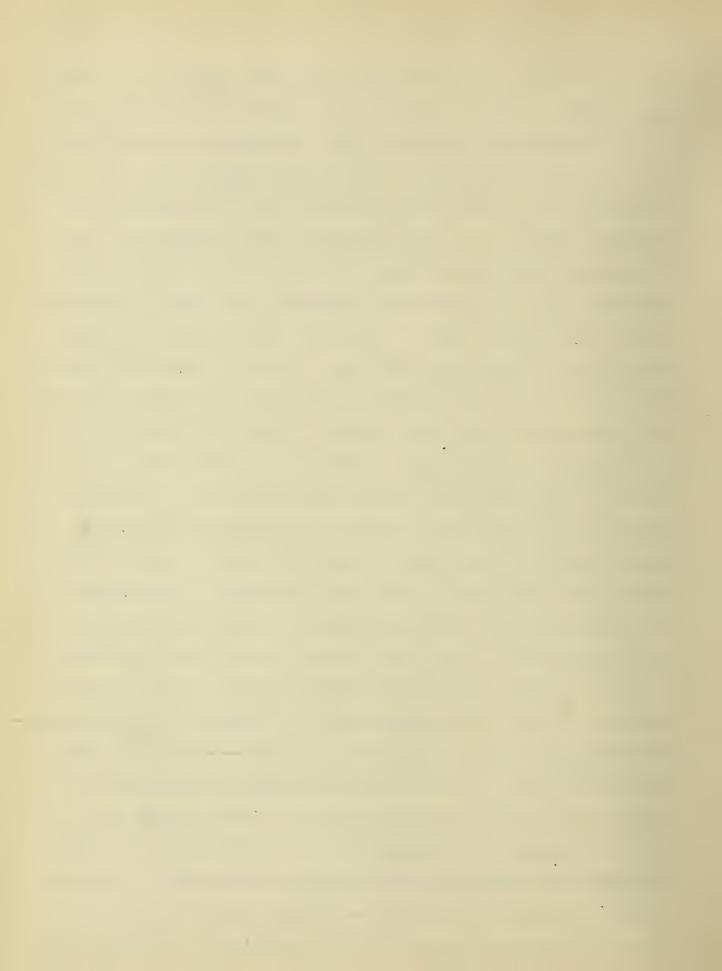
## WHERE DO THE CURCULIOS STAY DURING LATE SUMMER AND EARLY FALL?

Several attempts were made to locate the curculios during the late portion of summer. It was known then that part of the plum curculios were upon the trees but to find the others and the apple curculios was a problem. I began searching for these insects on August 14th and spent the greater part of the afternoon at this work. One plum curculio was found in the leaves at the base of a tree and another was hiding down under the bark in a crotch of a tree. Another search was inaugurated on August 17th but Anthonomus was not discovered although I looked through a great deal of trash under-



neath seven apple trees and several wild-crab bushes in an adjoining pasture. One plum curculio was found under the apple trees.

In the afternoon on August 18th a different method of search was installed. Heretofore, I had used my fingers alone as a means of separating the trash and my eyes were the only instruments of detecting insects. On this occasion I armed myself with a spade, a sand seive and a flour seive. With the former I shaved off a very thin layer of surface soil underneath some trash on the north side at the base of a tree. This soil, together with the trash, was carefully sifted and worked over. Several trees were operated upon in this manner and during the afternoon eight apple curculios and four plum curculios were secured. During the greater part of the forenoon on August 21st, I searched in the same manner and secured two plum curculios and three apple curculios. The apple curculios were taken from bunches of a wild grass (Elymus Cana-) densis) growing in the shade of some apple trees. Another apple curculio was discovered in some blue grass under a very densely foliated portion of a tree where there had been no cultivation. In the afternoon of August 28th I spent several hours searching carefully through the trash and leaves out away from the trees. Although I covered considerable area I did not find an insect; which would indicate that at this season they were found, in trash under shady trees. From an area containing approximately two square feet in some trash at the base of a Grimes Golden tree I secured three apple curculios and two plum curculios. No apple curculios were found in unshaded trash on August 31st. My attention was attracted by the fruit on a Janet tree on October 2nd. It had suffered from the work of both curculios so I determined to



see if any of the pests still remained in the leaves and trash.

From a handful of leaves and trash I sifted out two apple curculios and three plum curculios.

From these discoveries it seems that a great many, at least, of both curculios pass the late summer hid away in the trash and leaves in well shaded spots at the base of apple trees. Doubtless, they continue in such locations during the winter.

#### CATCHING CURCULIOS BY HAND

Quite a great deal of time was spent in catching curculios by hand while they were feeding upon the fruit. Sometimes the limbs holding the apple were jarred so that the insects tumbled off into the hand or hat placed underneath. The following table shows the results of this work giving the time of day when the insects were captured.

TABLE NO. XII.

CURCULIOS CAUGHT BY HAND.

Date	.Work in t	:No. Appl	ngs eNo. Plum scurculi- : os		:No. Apple:Gurculi-	:No. Plum
19	7:00-9:00	9	25	4:30-6:30 3:00 6:00 5:30-7:00 4:00-5:00 6:30 5:00-6:30 5:00-6:30 5:00-7:00	3 15 19 :	2 2 2 13 2 4

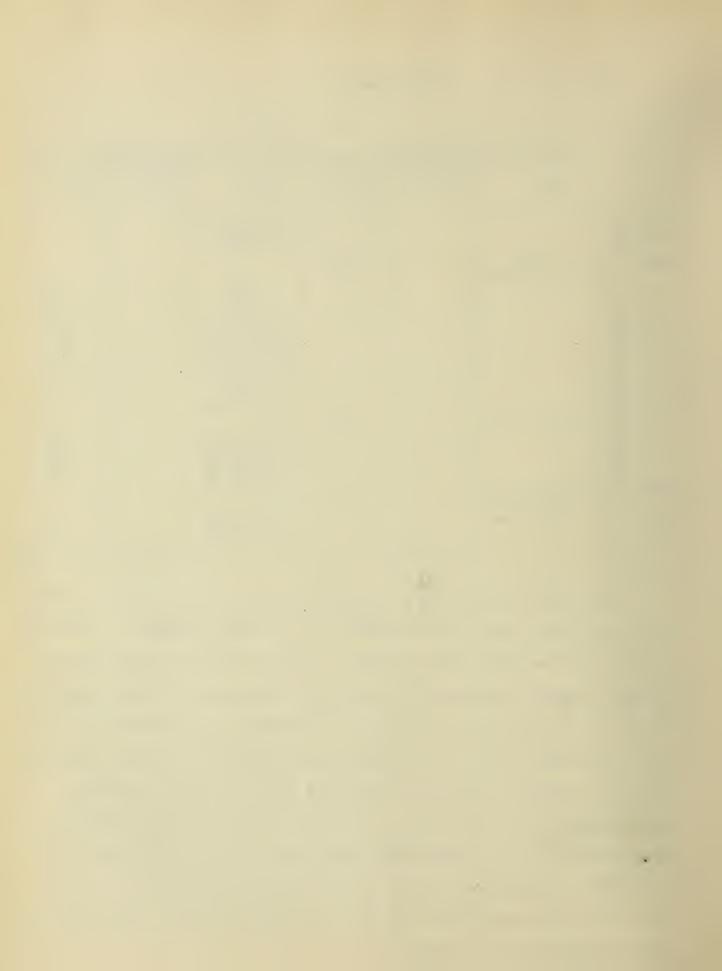


TABLE NO. XII. (continued)

	Work in the	morning	s :	Work in th	ne afternoon	ns
Date :	: No	o.apple: urculi-:	No. Plum: curculi-: os :	Hour	:No.apple::curculi-:	No. Plum curculi- os
July 30 : 31 : Aug. 7 : 8 : 10 : 11 : 13 : 14 : 17 : 20 : 21 : 22 : 26 : 28 : 31 : Sept. 5 : 12 : 0et. 1 : 2 : 2	9:00 11:00-11:40: 11:00-12:00: 4:45-5:15 not given		3 10	5:00-6:30 3:15 6:30 6:30 4:30-5:15 5:30-6:30 5:00-6:30 6:45 3:45-4:45 5:00-6:20 5:00-6:30 4:30-6:00 1:00-6:30 not given 4:00-6:00		10 1 25 25 23 23 3 3 39 16 31 26 4

This work was principly valuable because of the light it threw upon the season when the division of the broods occurred. The old apple curculios were found abundant up until the new ones came on which is shown to be about the middle of July, for at this time the first emerging beetles were found. However, in the case of the plum curculios there is a slight break between the broods; beginning about the middle of July and extending to the middle of August, practically none were found. This is the time when the greater proportion of these insects are pupating. It will be noted that no apple curculios were found after July 20th which seems to indicate that this insect does not do much damage to the apple after its first appearance as a beetle.

al



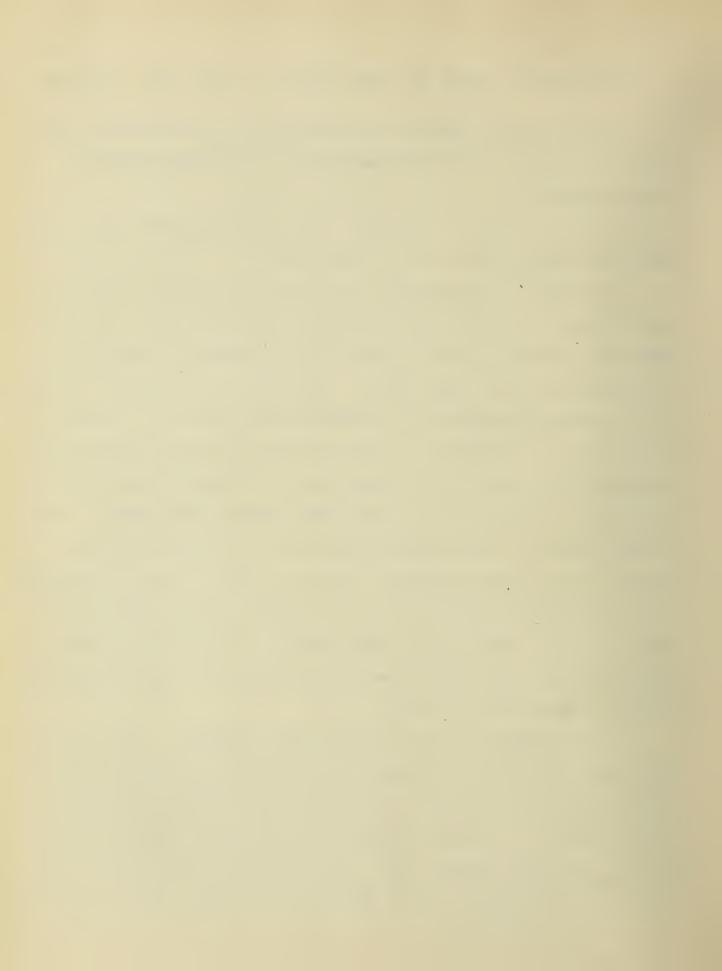
MISCELLANEOUS NOTES ON THE HABITS OF THE PLUM CURCULIO.

Several things regarding the habits of the plum curculio were noted during these investigations which of themselves contained no experimentation.

Larvae were found to measure 2 m.m. in diameter by 8 m.m. long. Pupae were 5.5 m.m. to 6.5 m.m. long and 3 m.m. to 3.5 m.m. wide.

The singing or chirping of the plum curculio often attracted my attention. I could never ascertain exactly how the noise was made but it seems to owe its origin to the rasping of the rear of the abdomen upon the wing covers. When the noise is made the rear of the abdomen is worked up and down corresponding to the chirps issuing from the curculio. When the tip of the wing covers were broken off the noise was no longer made. The music sounds very similar to the clicking of a mower when cutting heavy grass. When a large number of curculios were confined in a wooden box this noise could be distinctly heard across the room. They were noticed to make the noise when molested as in picking them up, burning by means of a hand lens and when threatened in any way or confined. Males, in some cases, were also noticed making the noise during the first preliminaries to mating.

Jarring causes them to drop and "play 'possum". In so doing they draw their two hind pairs of legs down close along the side of their body and have their feet extending partly across the abdomen. The forelegs are extended forward and then doubled backward enclosing the proboscis between them. The segments containing the feet are then again folded forward until the feet reach nearly to the tip of the down-curved shout.



Pupae in the burrow occupy a position in which their heads are always uppermost and they remain at an angle of about 45 degrees with the surface.

Larvae while in the fruit feed very much upon the flesh about midway between the surface and the core.

A plum curculio was found feeding on a blackberry on the morning of August 7th.

Owing to the gross feeding habits of the plum curculio larvae no instance was noted where apples remained upon the trees after the larvae had matured.

# HABITS OF THE APPLE CURCULIOS.

Lake the plum curculio, the most striking things as regards the habits of the apple curculio is the punctures which it makes in the fruit. These punctures may be classified as early feeding punctures, late feeding punctures and egg punctures.

Early feeding punctures of the apple curculio are characterized by their depth and narrowness. The insect probes its beak almost straight downward when making the punctures although it has to raise far up on its fore-legs in the beginning of the operation and nearly stands on its head before the operation is complete. The hole is made but very little larger in diameter than the proboscis.

Very little is apparently done on the sides of the puncture. After apples have grown to some size a great deal of the feeding work is confined to near the surface making a very bad blemish in the shape of solid scab of brown skin filled with depressions where punctures have been rade. The blemish is caused by the insect feeding on the skin and the flesh immediately under it.



The work as done by freshly emerged apple curculios is accomplished by eating very small holes in the skin and then probing the probiscis underneath and removing the adjoining flesh. During this work the beak is st uck almost straight out in front of the insect.

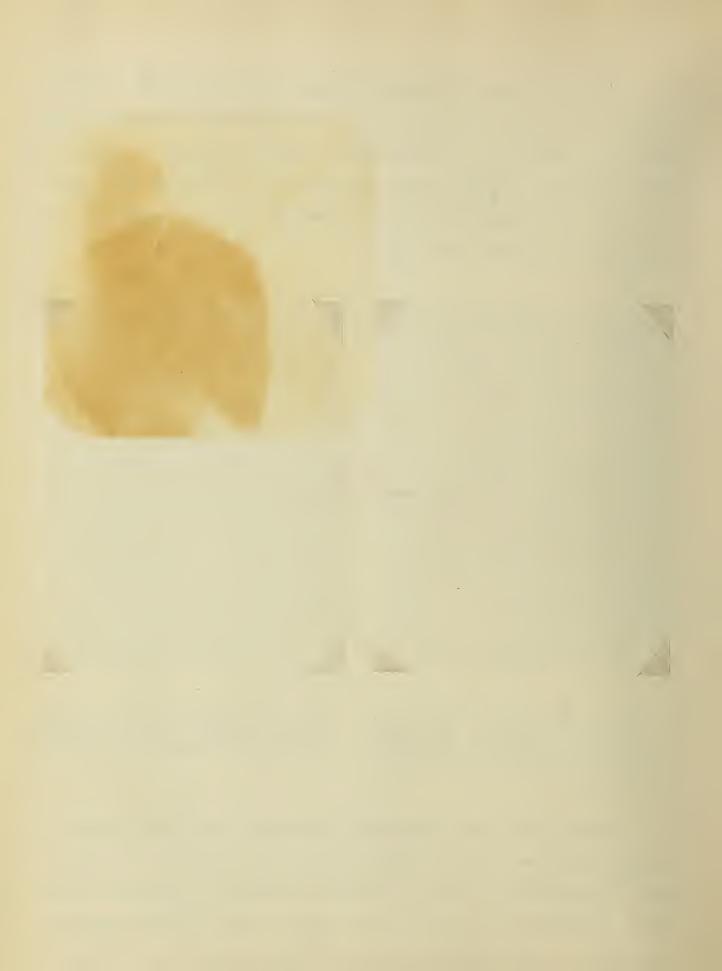
The following pictures are illustrative of the early and late feeding of the apple curculio.





Early Feeding Punctures of The late feeding work of the the Apple Curculio. The small apple curculio with the insect hole at the right of the bottom just after suspending operations. is an apple curculio feeding puncture.

The egg puncture of the apple curculio as well as the early feeding puncture is also characterized by its depth. In shape it may be described as a small channel leading into a conical cavity. These punctures are usually found closed by dark colored plugs of excrement. A photograph taken of a cross section of an apple



curculio egg puncture appears below.

when the fruit matures, either after a deep feeding or an egg puncture is made, it always has a depression leading to a dark streak, bordered by green, which penetrates the apple to the depth of the original puncture.

The thrity-three apples of which a record is shown for the plum curculio. in Table VII, were also examined for the punctures,



The Egg Puncture of the Apple Curculio in Cross Section.

eggs, etc. of the apple curculio. Only sixteen bore the marks of the apple curculio and the record of these is shown below with their number corresponding to those in Table VII.

## TABLE NO. XIII.

EXAMINATIONS OF APPLES FOR APPLE CURCULIO PUNCTURES,

LARVAE, ETC.

				Egg ncture						Larvae dead burrows
	:ur	es	:		:		:vae		:	
	:		•		:			•	*	
1	•	1	:		:					
2	:	1		1			*		:	1
7	:	13		2	:		:		:	1
8	:	2	:	1					:	1
9	:	45	:	2	:	1	:		:	1
11	:	3		2	•		*		:	1

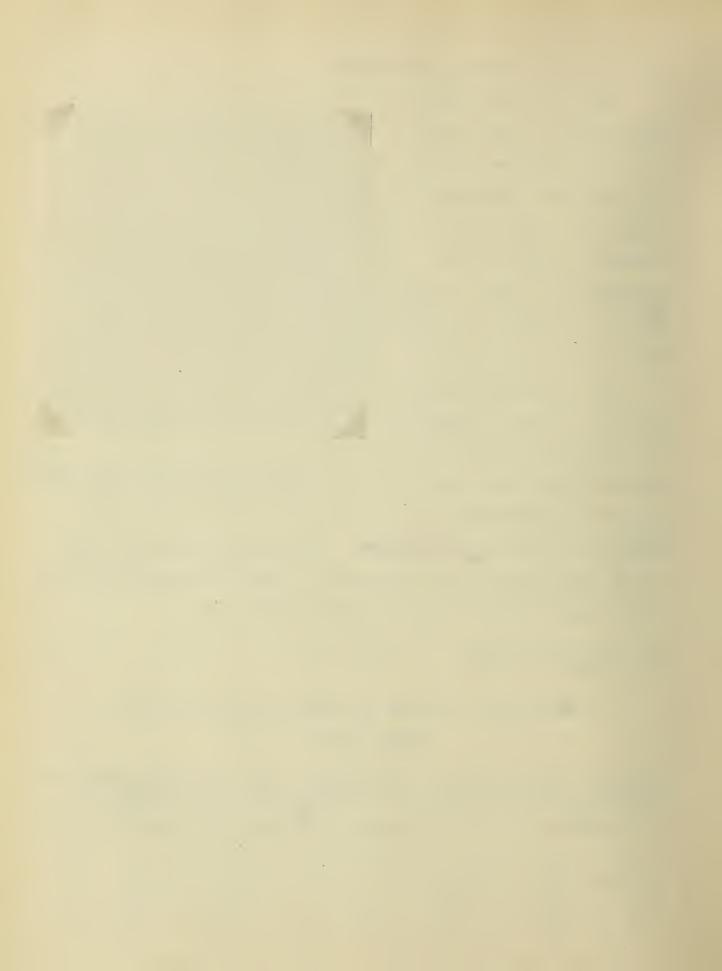


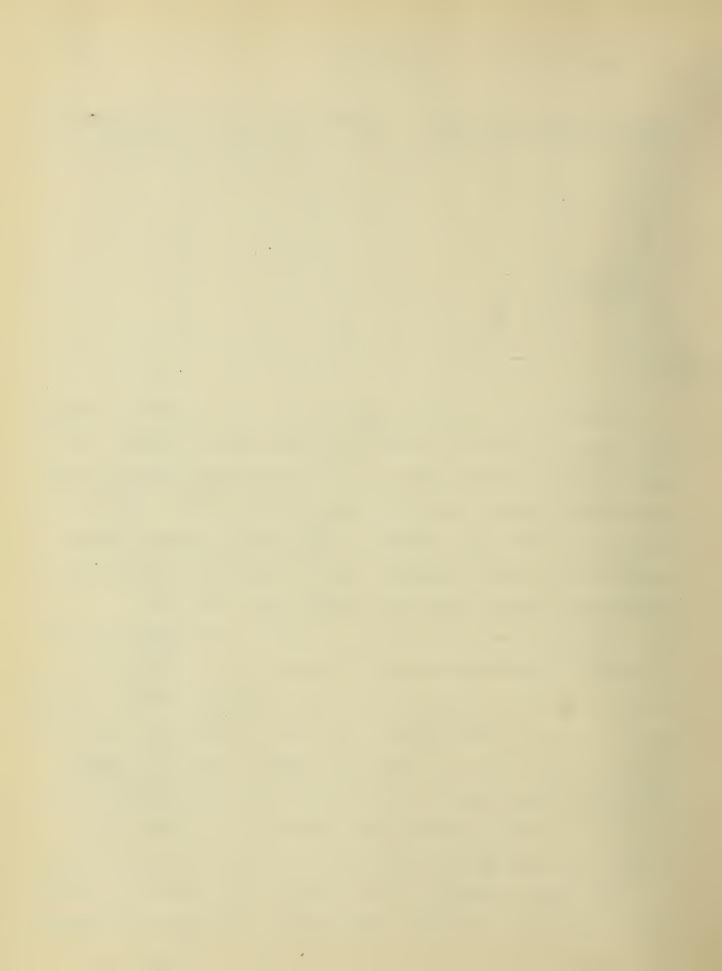
TABLE NO. XIII. (continued)

		o. Feeding unctures						:No. larvae dead :in burrows.
14	:	6	:	1	: 2	:	1	•
15	•	20	:		:	:		*
16	:	2						•
17	:	1	6 h		:	:		•
23	:	9					*	:
28	:	2			:			:
29	:	5			:			•
30	:	10	:	1	: ]			:
31		2	:					:
33	:	9	:	5	: 2	:		•
-	4		:			:		0

Examination of the 195 apples on July 16th previously reported were found to contain, two apple curculios ready to emerge, five apple curculio larvae, twenty-three apple curculio cavities where beetles had emerged, and three apple curculio pupae. While in the orchard gathering these apples from the ground I noticed quite a number of those upon the ground bore the distinctive holes which characterize apples which have harbored apple curculios.

Previous to this examination a number of apples were cut and examined on July 14th with results showing that in most every wrinkled shriveled fruit a plum or apple curculio larva was found. Nine apple curculio beetles and two apple curculio pupae were discovered and one fruit was found from which an adult had emerged. Similar work was pursued on July 15th, when three pupae and four beetles of the apple curculio were found in the fruits. Nine fruits were examined from which apple curculio adults had emerged.

From these records it can be seen that the work of the apple curculio was very marked and furthermore, that most of the beetles



emerged from the fruit about the middle of July.

MISCELLANEOUS NOTES ON THE HABITS OF THE APPLE CURCULIO.

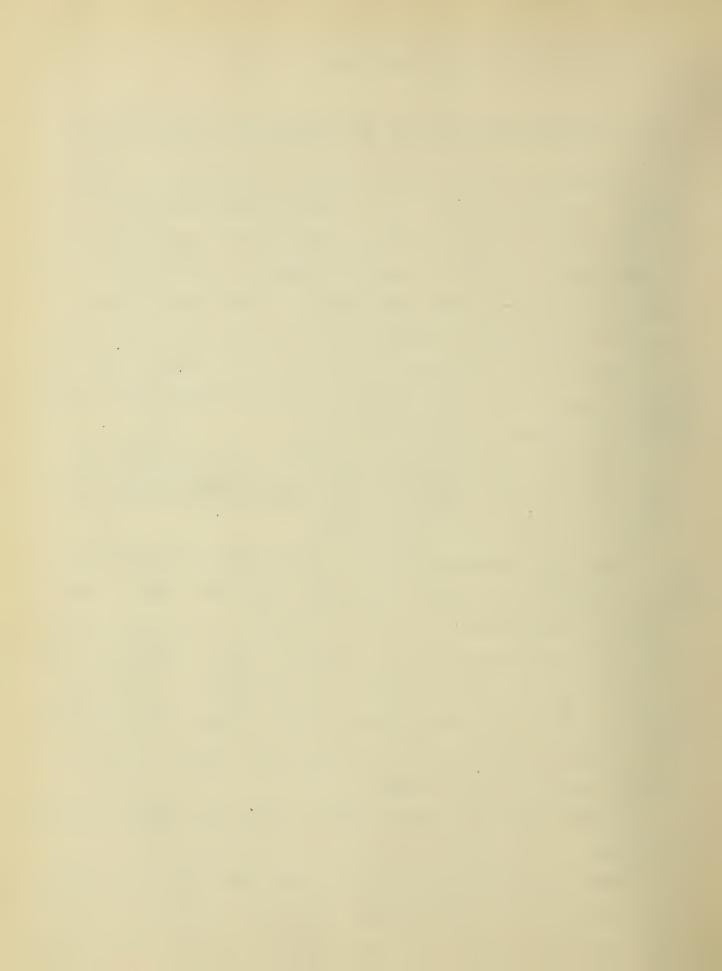
than is the plum curculio. It is a more "moody" creature and if it once takes a notion to hang to a tree, there it will hang with all its might. Several trials were made on the afternoon of July 4th to jar apple curculios from apples on which they perched. By means of a lead pencil I tapped the twigs gently at first and then increased both the frequency and severity of the blows. Some fell off the fruit at the least tap while others refused to fall regardless of the blows I rained upon the twig.

Apple curculios also "play 'possum" and when doing so fold their legs under the body with beak turned down do not get in as compact form as do the plum curculios.

The whole transformation, from egg to larva, from larva to pupa and from pupa to imago takes place within the fruit. The larva eats very little; usually it bores down by the side of the original egg cavity making a new cavity in which it pupates. Commonly in small fruits this pupal cavity is found in a seed cell. Plugs stopping the orifice leading to egg cavities form a perfect seal for the surface cells of the fruit grow tightly about it, thus holding it firmly in place.

Larvae and pupae appear somewhat smaller than those of the plum curculio.

The development of the apple curculio from egg to adult may take place while the fruit hangs to the tree. A shrivelled apple was taken from a tree on July 22nd which contained an apple curculio



pupa. Instances were noted where fruit, from which apple curculios had emerged, were still clinging to the tree. Though the apples were withered, it seemed that the stems were cemented to the twig.

### SPRAYING FOR THE CURCULIOS

A spraying experiment was conducted at Champaign in the Variety Orchard on the Experiment Station grounds; the aim being to ascertain whether or not spraying with Paris green would lend any assistance toward checking the damage of the curculios. As first outlined, the work included four apple and four plum trees, but the late freeze which occurred in the early morning of May 1st killed all the plums and left very few of the apples remaining upon the trees. Four Ben Davis trees were treated as follows -

Tree No. I was sprayed on April 15th, May 11, May 22, May 27, and June 27; making five applications in all.

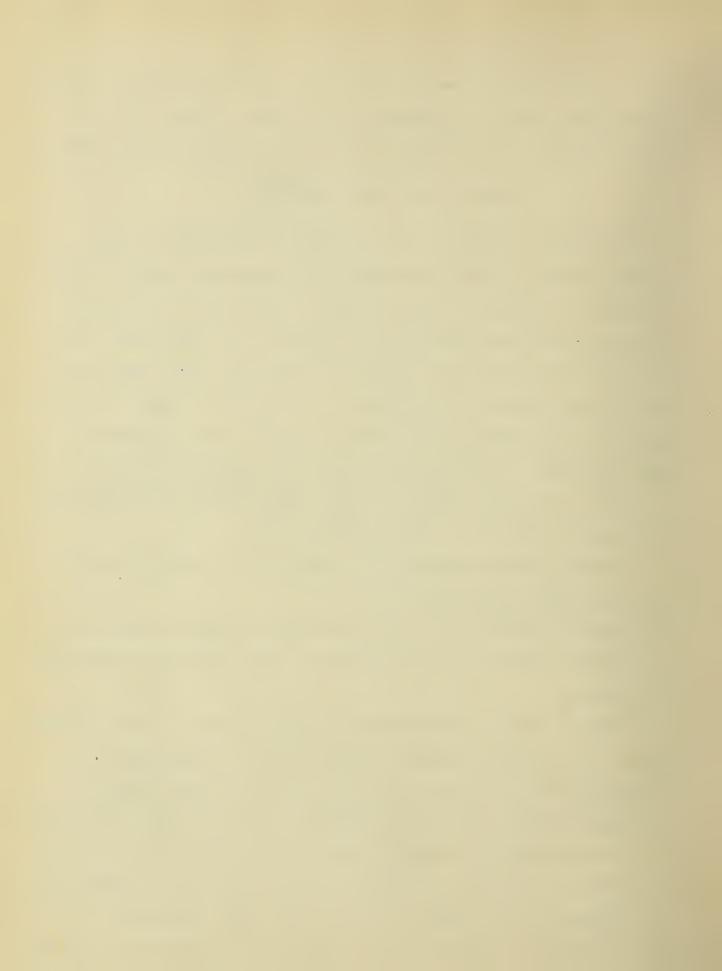
Tree No. II was sprayed three times, once on May 11, again on May 22, and finally on May 27.

Tree No. III received one application of spray on April 5.

Tree No. IV was used as a check and left unsprayed throughout the season.

These trees were surrounded by sprayed trees with the exception of No. II, which was bordered on the south by a bluegrass lawn; otherwise, the conditions were practically the same as regards previous treatment and treatment during the time of the experiment.

It was planned to apray Tree No. I as often as weather conditions made it necessary in order to keep a good coat of poison upon the foliage and fruit from the time of the first appearance of leaves until the season of egg-laying of the curculios was practic-



ally over. Tree No. II was treated very much the same as it would have been for the codling moth and apple scab only the first spraying was omitted and another application of spray was added. Tree No. III was sprayed once while the foliage was just opening in order that early feeding insects might be killed.

The blossom clusters were opening on April 15th when the first spray was applied, and the first bloom opened on April 20th.

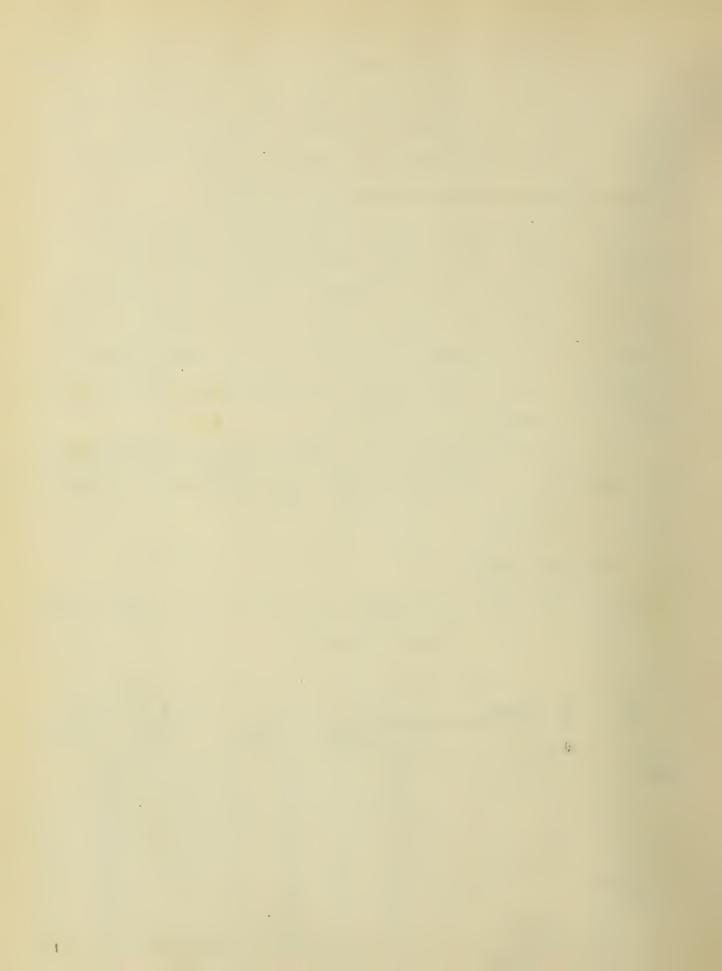
Record was kept upon the number of fruits, both windfalls and picked apples, which were punctured by the curculios. No attempt was made to separate the work of the two species but it was noticed that the plum curculio was responsible for the greater part of the damage done to the fruit.

The following table gives the record made upon the windfallen and picked fruit, showing the number of purctured and not punctured fruit for each tree.

TABLE NO. XIV.

RECORD OF FRUIT IN SPRAYING EXPERIMENT WITH PARIS GREEN
VERSUS CURCULIOS.

	,				:	-	:	-	:	*	
No.	of	Trees		1		I		II.		I	
Date	: K	ind of F	ruit :	Punct	Not:	Punct	Not:	Punct	Not:	Punct	Not
					punct	:	punct	: ]	ounct		punct.
	•			:			•		:		
June 9		Windfal:	ls :	59:	14:	467:	58:	307:	31:	152:	3
11		11	4	5:	:	19:	6:	13:		5:	
17		Ħ		3:	1:	59:	6:	33:	l:	24:	
26		<b>?</b> †	4	5:	:	77:	10:	63:	•	55:	
July 2		. 11	•	3:	6:	25:	23:	33:	6:	38:	5
14	:	11	7 1	9:	25:	43:	54:	35:	22:	39:	28
Aug. 8		17		13:	68:	38:	86:	62:	83:	54:	130
17		††		9:	5:	18:	7:	15:	9:	29:	3
Sept.22		19	4	56:	81:	122:	81:	213:	68:	154:	18
26	*	28		14:	10:	37:	29:	59:	10:	65:	6
26	*	Picked	4	45:	71:	546:	246:	275:	67:	310:	22_
		Totals		: 216:	281:	1451:	606:	1108:	297:	925:	215
				41							



The following table gives a summary of this data showing the total yield for each tree and the number and percent of fruits punctured and not pu ctured.

TABLE NO. XV.

PERCENT OF FRUITS ATTACKED BY CURCULIOS

No. of Tree	No.	: Not	elded : Total	•	Yield : Not :punctured
I	: 216	281	497	43.46	56. <b>53</b>
II	1451	606	2057	70.53	29.47
III	1108	297	1405	78.80	21.40
IA	925	215	: 1140	81./4	18.86

These data show a marked benefit for spraying in case of Tree No. I, while in the other instances, there is a slight difference in favor of spraying. It will be noticed that yield of apples in case of tree No. I was much smaller than with the other three trees. Some may argue that this is one of the reasons why the results of apraying seemingly show up so markedly. But to the author, the fact that the yield was so small would turn the argument the other way, because it was noticed at Barry that where trees were supplied with few fruits the damage by curculios was much more general than in instances where trees ore heavier loads. So, in the case of Tree No. I, it seems reasonable to suppose its fruits were not less subjected to attacks from curculios, but on the other hand, everything being equal, they would have had to suffer more

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+-6 3

4 g

than the apples from any other tree used in the experiment.

The final benefit of the spraying would be found in the number and percent of fuit which hung to the trees until picking time and still remained unpunctured. The following table is arranged in order to give this information.

TABLE NO. XVI

BENEFIT OF SPRAYING FOR CURCULIOS WHEN PICKED FRUITS

ARE CONSIDERED.

No. of	: No. Picke	ed Fruits	Yielded .	: Percent Y	
Tree	: Punctured	Not Punctured	: Total	: :Punctured	: Not :Punctured
I	45	71	: 116	38.80	61.20
II	: : 546	246	792	68.94	31.06
III	275	67	342	80.41	19.59
IV	310	22	332	93.37	6.63

The above table shows the lasting benefits of spraying trees for curculios. Whether or not all of this difference in favor of spraying was due to the poisonous effects of the spraying material, it is very difficult to predict. Nevertheless, owing to the general gradation of the benefits from the sprayed to the not sprayed fruits, it would seem that spraying was the important factor influencing the results.

From the data given in this experiment, spraying trees with Paris green is shown to be a very good remedy for curculios. The



strength of the mixture used included 4 oz. Paris green to fifty gallons of water; it is very probable that this amount of Paris green may be doubled without doing any great amount of damage to the foliage, thus making the mixture more effective as a remedy for curculios.

### SUMMARY OF INVESTIGATIONS

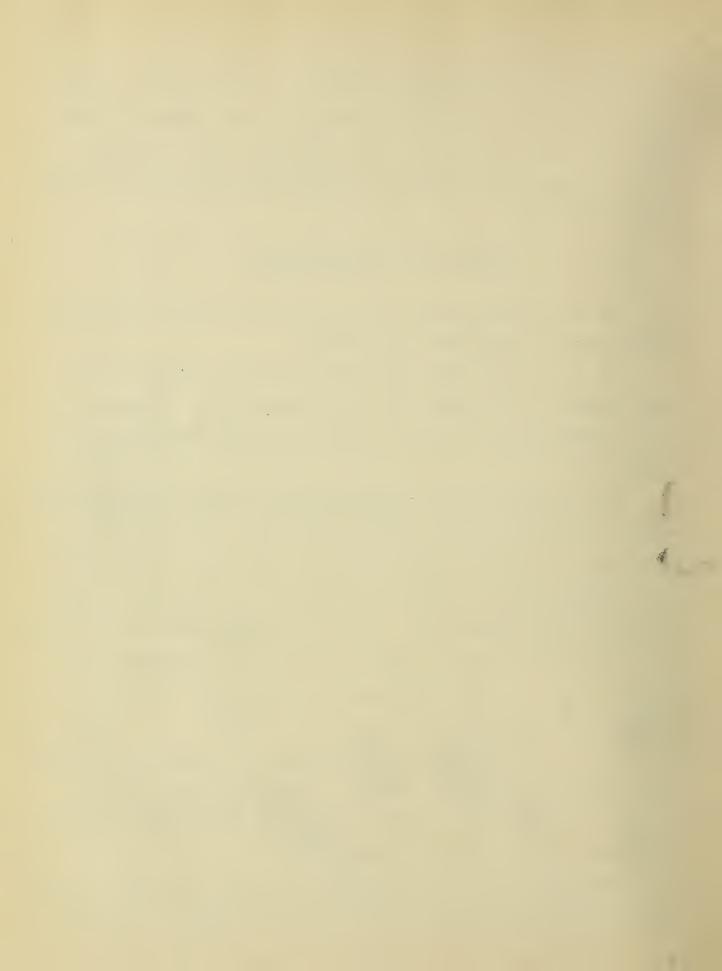
The following facts have been ascertained during the "Curculio Investigations" reported in this thesis -

The plum curculio may be poisoned by Baris green, but when sufficient quantities are used so that poisoning is produced in the minimum space of time it is very injurious to the foliage of trees.

Lead arsenate is an effectual poison for plum curculios when sufficiently concentrated mixtures are used. By using 15 oz. lead acetate and 6 oz. soda arsenate in preparing a mixture of four gallons, plum curculios were killed in 84 hours while apple curculios were not affected. This mixture when made into 50 gallon quantities would include 11 lbs. and 10 oz. of lead acetate and 4 lbs. and 8 oz. of soda arsenate the total cost at wholesale prices would be \$2.42.

Pupae of the plum curculio are killed by exposure to the air, sun, ants, and predactious insects. Cultivating to a depth of 1-1/2 to 2 inches under trees infested with this insect during the time of pupation will expose the pupae.

Exposing apples bearing larvae of the plum and apple curculios, in the sun, resulted in destroying 94% of the former and 100% of the latter.



Chickens will eat curculios, thus aiding in destroying the pests.

The plum curculio requires about 26 days to pass through the egg and larva stages when the larva emerge from the fruit, and burrows to a depth of 1/4 to 1-3/4 inches below the surface where it remains in the pupal form for a period, ranging in length from 22 to 41 days. Pupation of this insect was most abundant during the last half of July and the first half of August.

The first emerging apple curculio was observed on July 14th and the last emerging beetle came out between September 12 and October 2. Pupating forms of this beetle were found most abundantly during the month of July.

No second brood occurred with either species of curculios.

Tilth of the soil has practically no influence upon the depth of pupation of the plum curculio, though there is some indication that exposure to the sun has the effect of increasing the depth of pupation.

Curculios were not caught by means of trap lanterns.

A great many individuals, of both species of these insects, pass the late summer hid away in the trash at the base of apple trees.

Spraying experiments, conducted upon apple trees at the University for testing the efficiency of Paris green as a curculio destroyer, showed that 81.14% of the fruit was punctured when no spray was applied; while with 1, 3 and 5 applications of spray 78.80%, 70.53% and 43.46%, respectively of the fruit was punctured. Based upon the total fruit picked in the fall, where no spray was applied 93.37% of the fruit was punctured while where 1, 3 and 5 applications of spray were made 80.41%, 68.94% and 38.80%, respect-



ively of the fruits were punctured. The spraying material contained 4 oz. Paris green per fifty gallons of water.



"Curculios at breakfast and unknown posing for a picture."

This illustrates the characteristic manner in which the two species feed. They are feeding in this manner annually in orchards aggreatating thousands of arres.





